REPORT RESUMES

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HUMAN RESOURCES, TRAINING OF SCIENTIFIC AND TECHNICAL PERSONNEL. UNITED STATES PAPERS PREPARED FOR THE UNITED NATIONS CONFERENCE ON THE APPLICATION OF SCIENCE AND TECHNOLOGY FOR THE BENEFIT OF THE LESS DEVELOPED AREAS, VOLUME 11.

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PROBLEMS RELATED TO THE AVAILABILITY OF HUMAN RESOURCES IN LESS DEVELOPED AREAS OF THE WORLD ARE PRESENTED IN A SERIES OF PAPERS FROM A 1963 UNITED NATIONS CONFERENCE. AN INTRODUCTORY SECTION EMPHASIZES MANPOWER PROJECTION AND ASSESSMENT TECHNIQUES, PUBLIC MANAGEMENT, AND OCCUPATIONAL HEALTH AND SAFETY AS THEY RELATE TO ECONOMIC DEVELOPMENT. THE REMAINDER OF THE VOLUME IS CONCERNED WITH THE EDUCATION OF SCIENTIFIC AND TECHNICAL PERSONNEL AND IS SUBDIVIDED INTO (1) PLANNING POLICIES FOR THE DEVELOPMENT OF SCIENTIFIC AND TECHNOLOGICAL PERSONNEL AND (2) EDUCATIONAL PROGRAMS. TOPICS CONSIDERED IN INDIVIDUAL PAPERS INCLUDE--(1) POLICIES FOR THE INCLUSION OF SCIENCE, SCIENCE EDUCATION, AND TECHNOLOGY IN EDUCATIONAL PROGRAMS, (2) THE CURRENT STATUS OF PRIMARY AND SECONDARY SCIENCE AND MATHEMATICS PROGRAMS IN THE UNITED STATES, (3) TRENDS IN THE EDUCATION OF SCIENCE AND MATHEMATICS TEACHERS, (4) PROCEDURES IN CURRICULUM DEVELOPMENT, (5) DESIRABLE PRACTICES IN TEXTBOOK PUBLICATION, AND (6) THE IDENTIFICATION OF SCIENCE TALENT IN YOUTH. THIS DOCUMENT IS AVAILABLE FROM THE SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402, FOR $0.60. (AG)

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VOL. XI.

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Human Resources

Training of Scientific and Technical Personnel

Science, Technology, and Development

UNITED STATES PAPERS PREPARED
FOR THE UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND
TECHNOLOGY FOR THE BENEFIT
OF THE LESS DEVELOPED AREAS

SE 001 792

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VOLUME XI

Human Resources

Training of Scientific and Technical Personnel

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Science, Technology, and Development

UNITED STATES PAPERS PREPARED FOR THE UNITED
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OF THE LESS DEVELOPED AREAS

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Foreword

This collection of papers derives from an undertaking unique in the history of international cooperation.

In the spirit of the United Nations Decade of Development, delegations from all the member countries of the United Nations were invited to gather in Geneva, in February 1963, for a Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas. The purpose was to discuss, from the viewpoints of the scientist, the technical specialist, the planner, and the policy-maker, the many problems confronting the millions of people whose ways of life are being altered by social, political, and economic change.

All participating countries were invited to submit papers on a wide range of subjects pertinent to the purpose of the meeting. The response was of such magnitude that it was necessary to limit both the number and the length of the papers admitted to the Conference agenda. Since the U.S. Agency for International Development wished to make the total United States contribution available for future reference and study, it decided to publish in full all the American papers prepared for the Conference, including many not on the Conference agenda. (Titles of all the volumes in the series are listed on the inside of the front cover.)

In the series will be found contributions from men and women in United States universities and foundations, in business and in government. The authors were chosen as recognized experts and scholars in fields of special interest to developing countries; the opinions expressed in the papers are the authors' own and do not necessarily represent official positions of the United States Government. A number of the articles are collaborations of American specialists and professional colleagues from other countries in line with the expressed desire of the Secretary General of the Conference to have joint contributions illustrating the efficacy of cooperative projects.

These volumes supplement an already growing body of literature in the United States on the problems and processes of development, and on the experience and techniques which can be of use to those engaged in planning and carrying forward development activities. As a guide to this literature, the Agency for International Development has prepared a *Selected Reading List,* which briefly describes some 1,200 recently published American books and articles relevant to the subject matter of the Conference. The *Selected Reading List* has been published as a companion volume to this series. Most of the books and articles cited in it have been collected for display at the Technical Library of the Geneva Conference and for subsequent presentation to the Dag Hammarskjold Memorial Library of the United Nations in New York.

The Agency for International Development organized United States participation in the Geneva Conference by establishing an ad hoc Science Conference Staff, directed by Mr. David Tilson. This staff was a division of the Research, Evaluation and Planning Assistance Staff, directed by Dr. Edward C. Fei.

In approaching its task, the Science Conference Staff depended for advice and assistance upon a Public Advisory Board, a series of Technical Advisory Panels selected to cover each of the main subject areas on the Conference Agenda, and on a Steering Committee consisting of Mr. Harlan Cleveland, Assistant Secretary of State for International Organization Affairs; Dr. Walter Whitman, Science Advisor to the Secretary of State, and Dr. Jerome Wiesner, Science Advisor to the President.

The Public Advisory Board was appointed by the Secretary of State and consisted of the following members: Dr. Walsh McDermott, Cornell University Medical College, (Chairman); Dr. Detlev W. Bronk, President, Rockefeller Institute; Dr. Harrison S. Brown, Foreign Secretary, National Academy of Sciences; Dr. Robert A. Charpie, Director, Advanced Projects Research, Union Carbide Company; Dr. Frederick H. Harbison, Princeton University; Dr. J. George Harrar, President, Rockefeller Foundation; Dr. J. Herbert Hollomon, Assistant Secretary for Science and Technology, Department of Commerce; Dr. Allan R. Holmberg, Cornell University; Mr. William A. W. Krebs, Jr., Vice President, Arthur D. Little, Inc.; Dr. Isador Lubin, The Twentieth Century Fund; Dr. Max F. Millikan, Center for International Studies, Massachusetts Institute of Technology; Dr. Robert Morison, Rockefeller Foundation; Dr. Arthur T. Mosher, Executive Director, Council on Economic and Cultural Affairs, Inc.; Dr. Frank Press, California Institute of Technology; Dr. Isidor I. Rabi, Columbia University; Mr. Thomas J. Watson, Jr., Chairman of the Board, International Business Machines; and Dr. Jerrold R. Zacharias, Massachusetts Institute of Technology.

The Technical Advisory Panel for *Human Resources* consisted of Dr. Isador Lubin, The Twentieth Century Fund, and Dr. Frederick Harbison, Princeton University. Dr. Eugene D. Vinogradoff, Department of Labor, acted as Scientific Secretary.

The Technical Advisory Panel for *Training of Scientific and Technical Personnel* consisted of Dr. Arthur Roe, National Science Foundation (Chairman); Dr. Bowen C. Dees, Mr Howard F. Foncannon, Dr. Philip W. Hemily, and Mr. Thomas J. Mills, all of the National Science Foundation; the late Dr. Francis L. Friedman, Massachusetts Institute of Technology; Dr. Dael Wolfle, Executive Officer, the American Association for the Advancement of Science. Mr. Robert F. Hull, National Science Foundation, acted as Scientific Secretary.

Mr. John H. Durston and Mr. Norman J. Meiklejohn served as editors of this series of volumes.

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PART I

HUMAN RESOURCES

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Introduction

In the eyes of the political leader and the economist, as well as the man in the street, the primary function of science and technology is to improve human welfare. To them science and technology are tools which, when properly applied, can help the environment to yield more and better food, more and better housing, more and better education, and better health. On these benefits to human welfare depend the kind of stable society that is essential to the existence of free political institutions.

The availability of science and technology does not guarantee, however, that the economic development of a country automatically will be furthered. If science and technology are to contribute to the productive process, special talents must be developed and the population must be trained to apply the knowledge and techniques effectively on a broad front. The availability of people with the necessary skills determines the direction and the rate of the economic growth of the developing countries. In the end, it will be the ambitions and the know-how of the peoples of the developing countries that will determine whether minerals will stay in the ground or be transformed into goods useful to man; whether oil remains hidden or becomes a major source of power and heat; whether roads remain mud tracks or are transformed into arteries for trade and commerce; whether education will be available for youth; whether the old will be cared for.

In short, the most important investment any country can make, whatever its stage of economic development, is in its human resources, that is, in the education and training of its population under institutions which create incentives and make it possible for the individual to realize his aspirations.

The experience of the United States reflects the importance of training and skill in an environment that stimulates imagination and initiative. It is still within the memory of living man that sheer human brawn was the basis of wresting a living from the American wilderness, of building homesteads and developing farms, roads and commerce. It is only recently that most of the great advances in science and technology have taken place, and it has been only in the present century that these advances have been widely adapted to the practical use of man in his daily life.

For generations the United States borrowed its technical knowledge from other countries and depended on foreign universities to educate many of its youth. Indeed, up until the early years of this century, the United States was largely dependent upon immigrants from foreign lands as the source of a considerable part of its skilled labor force.

The real industrial revolution in the United States began with the wide spread of universal education at the elementary school level. Today, almost all the young people graduate from elementary school. Two-thirds graduate from high school. More than one-third of the youth of university age are in institutions of higher learning. The result has been an overwhelming increase in the number and the quality of skilled and professional people.

With the "explosion" in education came a shift from a primitive agrarian economy to an industrial economy with an ever-increasing supply of goods and services. With it came also a change in the place of the United States in the world economy. The United States became an exporter not merely of agricultural and industrial products but of the methods and techniques which make the increased production of goods possible.

Today there is no reason why a developing country should proceed laboriously along the paths trod by the United States and the industrial nations of the Western world. The policies and programs developed over the decades to improve the quality and the utilization of the labor force can in large part be transferred to the developing areas and adapted to their needs. The papers which follow stress the importance of the native population as an integral and major factor in any plan for the accelerated application of science and technology.

In "High-Level Manpower Development and Economic Growth" Professor Harbison points to the direct relationship that exists between the prevalence of high-level manpower and the rate of economic growth in various countries and suggests methods of accumulating an adequate supply of such manpower. He emphasizes, however, that of almost equal importance is the efficiency with which the supply of such human resources is employed. In many instances, highly trained people are being employed on jobs beneath their skills because of the unavailability to the economy of persons with lesser intermediary skills.

The important bearing of population growth and distribution upon balanced economic development is emphasized by Professor Hauser in "Population and Labor Force Resources". Rapid population increases, he states, may be a major obstacle to economic development. Other factors, he points out, such as adverse population distribution (i.e., higher proportion of urban population, unfavorable age structures and inadequately educated and trained manpower) also stand in the way of attainment of balanced economic development.

In order that there may be an assured supply of manpower with the required education and skills, it will be necessary to know what a country's future needs for labor will be. To ascertain this need requires an assessment of the current labor supply. In dealing with this problem of "Manpower Projections and Techniques", Dr. Wolfbein makes suggestions as to how the necessary information can be secured; he reviews projection techniques employed in the United States and discusses how Manpower projections can be used in developing countries.

Messrs. Saks and McVoy, in their paper, "Techniques of Manpower Assessment", describe the types of statistical data that are necessary for translating economic development objectives into Manpower needs which they illustrate from their experience in a developing country. They place great stress on the importance of secondary, higher technical, and professional education in attaining balanced economic progress.

Manpower, of course, ranges from top management to unskilled labor. Professor Hoselitz's paper deals with the crucial importance of entrepreneurship not only in private enterprise but also in those branches of Government which are responsible for public investment and economic planning. He examines the problem in relation to commercial, financial, and industrial activities and points out the different qualifications which persons performing entrepreneurial roles must have to operate successfully. He also discusses the sources of entrepreneurial talent, the possibilities of training such talent, and the establishment of conditions favorable to the exercise of entrepreneurial activity.

Messrs. Toulmin & Chandradhat also deal with the problem of entrepreneurship in their discussion, "Improving Public Management in Newly Developed Countries". They point to the fact that the importance of public management to national development is often less appreciated than some other development prerequisites and suggest methods that may be used for improving public management in a developing country. They point to the need of fitting the method of improvement to the situation prevailing in each country and give particular emphasis to the care that should be exercised in the selection of key officials if development is to be successful.

A detailed narrative report of training techniques and an assessment of their efficacy is given by Dr. Ewing in his paper, "Skilled Manpower Training to Support Industrial Growth in a Developing Nation". Among other matters essential to a workable training program, he concludes, are the requirements for a suitable administrative organization and the fact that the people involved must understand the training plan proposed and be ready to participate in it. He also discusses the criteria for determining the trades in which training should be offered, the problem of physical facilities, and the preparation of the necessary teaching staff.

Dr. Lawrence refers to the ethnic, social and cultural barriers to economic progress that exist in certain developing countries. In his opinion, as expressed in "Some Aspects of Management and Skilled Supervision," the system of "Training within Industry" is a most suitable instrument for overcoming these barriers, particularly since it improves the supply of supervisory employees.

In the field of industrial hygiene Dr. Landry and Mr. Ochoa cover their experience in setting up an organization for training personnel to evaluate and control occupational hazards in agriculture, industry, and mining. Their paper, "Development of Latin American Specialists in the Chemistry of Occupational Health," presents suggestions for training specialists and for applying advances in science and technology to the elimination of industrial diseases in the developing areas of the world.

The contribution that women can make to economic development is discussed by Assistant Secretary Esther Peterson's paper, "Women in the Labor Force." In describing the part played by women in the American economy, she notes that they constitute a third of the United States Labor Force and are important in almost every occupational classification. She recommends the enactment of legislative standards for the protection of women workers by the developing countries if they wish to use their resources of female labor most productively. She particularly emphasizes the growing importance of education in providing the skills required for newly developing jobs.

Virtually every discussion of human resources as related to economic development makes much of the basic importance of health and nutrition as an ingredient in the efficiency of the labor supply. In the category of health preservation is industrial hygiene and industrial safety.

Commissioner Clague, in dealing with "Occupational Safety in a Newly Developing Industrial Area," points out that occupational safety is in fact a way of life in which workers, management and Government must all participate. He stresses the fact that it must be rooted in a sincere respect for "the dignity, physical well-being and economic welfare of the individual". He goes on to say that if an accident prevention program is to be successful, it must be established by law and enforced against reluctant employers. He makes it clear, however, that Government action alone is not sufficient to achieve a satisfactory standard, and that if progress is to be made, there must be vigorous support for any accident prevention program by the voluntary action of both employers and employees.

Together, these papers seek to present a wide array of problems that must be resolved if economic development is to proceed at an accelerated and orderly pace. All are concerned with bringing the indigenous populations of the developing countries up to the point where they can make their maximum contribution through the use of science and technology to improving human welfare. They stress the importance of management and leadership not only in Government but also in private enterprise. They outline methods for imparting the skills that are essential to the operation of modern industry, commerce, agriculture, and mining. They make it evident that any advance in economic efficiency, whether it be upon the land or in the factory, must be based on the recognition of individual dignity and individual welfare.

The authors of the various papers agree unanimously that if economic development is to yield a better life the primary investment required for the developing countries is in human beings—that is, the education and training of the population—so that the countless activities involved in the utilization of modern science and modern technology may be directed and carried out efficiently.

Isador Lubin,
The Twentieth Century Fund.

High-Level Manpower Development and Economic Growth*

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Human Resources and the Wealth of Nations

1. The wealth of a nation depends ultimately upon the productive skills and the levels of education of its people. And its rate of social and economic growth will be dependent in significant degree upon its rate of human capital formation. Thus, investment in the development of man should be a primary concern of every nation which hopes to make forward progress in the modern world. Progress, of course, is related to the general levels of education and skills of a country's entire population, but it is even more intimately connected with the development of its strategic or high-level manpower. This paper is concerned with the logic of high-level manpower development in relation to general social and economic growth.

2. Any definition of strategic or high-level manpower must be somewhat arbitrary. For the purposes of this paper, we shall assume that it includes all persons who have twelve or more years of formal education or its equivalent in skill and experience. Accordingly, in most countries this definition will encompass all professional personnel including scientists, doctors, engineers, architects, agricultural officers, veterinarians, lawyers, university professors, etc. It includes all senior administrators, executives, managers and principals of sizable establishments in government, industry, commerce, transportation, etc., as well as political leaders, officers of police and armed forces, judges, and senior union officials. One definition also includes all subprofessional personnel in agriculture, industry, commerce and the public services, such as nurses, higher supervisory personnel, chief clerks, and technicians of all kinds. Highly skilled artisans and craftsmen are also included. Finally, we include teachers in secondary schools, technical institutes, teacher-training institutions, and vocational schools. In the more advanced countries, primary school teachers would also be classified as high-level manpower, but in most of the less developed countries their educational and skill level would generally be beneath the high-level manpower category.

3. Our arbitrary definition thus covers all of the leadership groups and their technical associates. It includes, as well, the upper echelons of teachers. It en-

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*UN conference paper.

compasses a country's ruling elite, but includes in addition many others. In short, it takes in all those persons possessing knowledge and skills which are critical for a country's development.

Strategic Human Capital as a Measure of Economic Advancement

4. The stock of high-level manpower possessed by a country is perhaps one of the best indicators of its stage of economic and social advancement. In the most advanced countries, for example, the number of persons with 12 years' education or its equivalent probably exceeds 100 per 1,000 population. In such countries, primary education for 6 years is both universal and compulsory. Well over 50 percent of the 14–17 year age cohort is in secondary schools, and over 10 percent of the 18–20 cohort is enrolled in some form of higher education. In the more primitive underdeveloped countries, on the other hand, only one person per 1,000 population may have 12 or more years of education. In these countries, less than a third of the 7–13 year age cohort is in primary school; less than one percent of the 14–17 group is in secondary school; and only a handful of individuals are enrolled in higher education either at home or abroad. Between the primitive countries and the very advanced countries lie most of the less-advanced and the more-advanced underdeveloped countries of the world.

5. In general, the stage of a country's development as measured by these human resource indicators shows a positive correlation with its stage of development as measured by estimates of national income per capita.[1] However, the relative differences between some advanced and less developed countries may be greater in terms of high-level manpower than in terms of per capita national income. The following table, which is presented purely for illustrative purposes, shows this quite clearly:

Country	Number of persons per 1000 population with at least 12 years education	National income per capita (in U.S. dollars)
Nigeria	.8	64
Egypt	10.7	110
Italy	31.4	594
U.S.S.R.	112.6	721
United States	288.0	2800

6. Italy, for example, has 39 times more persons per 1,000 population with 12 years or more education than Nigeria, but its national income per capita is only about nine times that of Nigeria. Similarly, the U.S.S.R. has a per capita stock of high-level manpower 11 times greater than Egypt, but its national income per capita is only seven times greater. On the other hand, relative differences in stock of high-level manpower and national income in the United States as com-

pared with Egypt are about the same, while the comparison between the United States and the U.S.S.R. shows a greater relative difference in national income per capita than in stock of high-level manpower.

7. Because of the obvious technical difficulties in constructing accurate measures of the stock of high-level manpower and national income (which lie beyond the scope of this paper), one should be most cautious in relying too heavily on statistics such as those presented above. Nevertheless, they do give some indication of possible relationships between the development of high-level manpower and general economic development. And by using more refined qualitative and quantitative human resource development indicators, it is possible to make more precise and sophisticated distinctions between countries at various stages of progress.[2] The only point being stressed here, however, is simply the importance of using some measure or measures of human resource development when analyzing the problems and prospects of economic and social growth in newly developing countries.

High-Level Manpower Requirements and Economic Growth

8. On the basis of preliminary studies in 30 countries at various stages of development, it is possible to make some tentative generalizations regarding the relationship between high-level manpower and general economic development. Although these generalizations need to be refined, qualified, and used with caution, they may serve as rough guide lines for policy planners. In brief they are as follows:

(a) In all developing economies the rate of accumulation of high-level manpower exceeds the rate of increase of the total labor force. In the United States, for example, the increase in high-level manpower during the past 50 years is certainly more than twice as great as the increase in the nation's labor force. This has been true also of the Soviet Union. And it is probable that most newly developing countries in their early stages of growth may have to increase high-level manpower at least three times as rapidly as the increase in their labor forces, if they are to achieve a rise in per capita income of 2 percent or more a year. Within the high-level manpower category, of course, certain critical occupational groups, such as engineers, technicians, agricultural experts, and secondary school teachers may need to increase at a much more rapid rate, whereas lawyers and arts graduates should probably increase at a more moderate pace.

(b) In most countries, the rate of increase of high-level manpower (or the rate of strategic human capital formation) also will exceed the rate of economic growth. In newly developing countries which already have critical shortages of highly skilled persons, the ratio of the annual increase in high-level manpower to the annual increase in national income may need to be as high as 3 to 1, or even higher in those cases where expatriates are to be replaced by the citizens of the devolping country. In more advanced societies, which already have a sizeable stock of high-level manpower, this ratio may be considerably lower. Here again the ratios of increases of particular occupational groups within the high-level manpower category are even more significant than the ratio for the high-level manpower group in the aggregate.[3]

(c) Equally important as the rate of high-level manpower accumulation is the efficiency with which it is employed. In the newly developing countries in particular, high-level manpower may be poorly utilized because of a poor balance of skills in relation to needs. There may be too many lawyers, and too few engineers and technical foremen. Doctors may not be utilized effectively because of a shortage of nurses or medical technicians. In many countries fewer highly trained engineers would be needed if there was a more adequate supply of engineering technicians. In nearly all newly developing countries, highly trained people may be employed on jobs beneath their skill merely because there is a more critical shortage of persons with lesser intermediate skills. Thus, as in the case of capital funds, the proper utilization or "investment" of high-level manpower may be as important as its rate of accumulation. Here the patterns of incentives which education generates, the types of persons produced, and the manner in which they become allocated to strategic activities are of supreme importance.

(d) The required rate of accumulation of high-level manpower in a developing society is related to change and innovation in economic, social, and political life. A static society usually requires very few persons in the high-level manpower category. But as a static society begins to modernize, it must accumulate high-level manpower of all kinds to staff a new and expanding government service, to introduce new systems of land use and new methods in agriculture, to develop new means of communication, to carry forward industrialization, and to build a system of education. Changes in all these fields require large inputs of persons with professional and technical skills and organizing ability. The more rapid the changes, the more intensive will be the use of high-level manpower.

The Accumulation of High-Level Manpower

9. Granted the strategic importance of high-level manpower for a country's economic advancement, how can it be accumulated? Or, to use the terms of the economist, what are the major processes of human capital formation in newly developing societies?

10. Obviously, high-level manpower may be developed through investment in formal education—i.e., in schools, technical training centers, colleges, universities and other institutions of higher education. But this kind of development takes a long time. For example, it takes 8 to 10 years to make a qualified engineer out of an 8 year primary school leaver. It takes longer to train a good scientist or a competent doctor. Even nurses, secondary school teachers, and engineering or agricultural technicians require 4–6 years of training beyond the eighth grade before they can be considered qualified. Indeed, in planning ahead a country must assume that its potential new additions to high-level manpower stock from domestic sources for at least 15 years in the future, are presently in school. Thus, no broadening of the base of primary education will have much effect upon the development of high-level manpower within that time-span. The rate of accumulation of high-level manpower

within the 15 year period can be increased only through investment in education at higher levels of those who are already in school.

11. Fortunately, however, there are other ways of accumulating high-level manpower and accelerating the rate of its development. High-level manpower may be imported from abroad through a variety of means such as technical assistance, expatriate enterprises, hiring of consultants or encouragement of immigration. It may be developed in employment through on-the-job training, in-service programs of education, management development seminars, part-time adult education classes, and many other means. High-level manpower may also be developed in employment through better organization of work, the creation of productive attitudes and incentives, and better management of people. And, of course, the development of people is assisted at all levels by improvements in public health and by better nutrition.

12. The task of the newly developing country, therefore, is to devise a logical strategy of high-level manpower development, and to relate this strategy to its broader objectives of economic growth. We shall conclude this paper with a brief listing of the elements of such a strategy and the measures which may be employed to implement it.

A Strategy of High-Level Manpower Development

13. A strategy of high-level manpower development has these essential components: the rational development of formal education; the promotion of effective training of employed manpower; the building of incentives which are appropriate for a productive society; and the temporary use of foreign personnel to fill positions requiring skills which are unavailable within the country. These four elements are interdependent. Progress in any one area is usually dependent upon coordinated progress in the other three as well.[4]

14. It is obvious that a strategy of high-level manpower development involves much more than a program for development of formal education. Indeed, investments in formal education are likely to contribute effectively to rapid growth only (a) if there are adequate incentives to encourage men and women to engage in the kinds of productive activities which are needed to accelerate the modernization process and (b) if appropriate measures are taken to shift a large part of the responsibility for training to the principal employing institutions whether they be public or private. A well-defined strategy of high-level manpower development therefore requires a sound program of wage and salary administration, a program for training-on-the-job, a program for the importation of critical skills, as well as a program for investment in formal education.

15. The program for developing formal education, however, is perhaps the most difficult and certainly the most costly element in the strategy. And, here countries with limited resources have some hard choices to make. In most of the newly developing countries, priority must be given to investment in and the development of broad secondary education, and in poor countries, this may require the temporary postponement of achievement of universal primary education. And, with regard to higher education, most of the newly developing countries may need to give priority to the building of intermediate level training institutions

and to the expansion of the scientific and engineering faculties of universities. A country committed to rapid economic progress needs to make careful assessments of the future demand for various categories of high-level manpower, and to some extent it will have to shape its program of investment in education to meet this demand. For this reason, education policy should not be left exclusively in the hands of educators or education ministries. It must be influenced at strategic points by those who are concerned with the general problems of economic growth.

16. The analysis set forth suggests that most newly developing countries might be well-advised to establish some kind of human resource strategy board to plan and coordinate the various programs which are necessary for the rapid accumulation of high-level manpower. Such a board should have broader responsibilities than a statistical agency, a study commission, or a long-range planning organization. Although primarily concerned with policy formulation, the human resource strategy board should be involved in day-to-day coordination of activities of various ministries and employing institutions. It thus would have both advisory and executive responsibilities. Its top staff, therefore, should be neither statisticians, professional educators, or economists as such. Rather its key personnel should be strategists—persons who combine political insight with a rational understanding of the processes of economic and social growth in this Century of Science.

FOOTNOTES

[1] The data presented here regarding the relationship between human resource development and general economic growth are taken from a study in progress by the author and his associates at Princeton University. This study is entitled *"Models of Human Resource Development in Modernizing Societies."*

[2] Some of the indicators are as follows: enrollment in educative institutions of different levels and types; numbers of professional personnel (doctors, engineers, scientists, etc.) per 1,000 population; university graduates per 1,000 population; dependence on non-native high-level manpower in senior positions in major public and private institutions; rates of population increase; and percentage distribution of the labor force in primary, secondary and tertiary industries.

[3] This hypothesis suggests that, on the basis of comparative research in a number of countries at different stages of growth and with different patterns of development, it might be possible to devise "multipliers" to estimate future requirements of strategic occupational groups in relation to projected growth patterns and growth rates for an economy. Such "multipliers," of course, would be particularly useful in planning investments in various kinds of education. In this way, the programming of investments in human resource development could be integrated effectively with planning for general economic growth. Admittedly, much empirical evidence would need to be accumulated to build reliable "multipliers" of this kind. And, if such "multipliers" are to be useful for policy planners, one would need to construct them for various categories of critical occupations. From a theoretical standpoint, however, the concept of "high-level manpower to growth ratios" is a useful tool

of analysis, parallel in many respects to the marginal capital to output ratio in economic analysis.

[4] For a fuller description, Frederick Harbison, *Human Resources Development Planning in Modernizing Economies,* International Labour Review, *85,* No. 5, (May 1962).

Population and Labor Force Resources As Factors in Economic Development*

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1. Economic development has as its objective the raising of the level of living of a people. The population of a nation, however, not only reaps the gains of economic development through increased per capita income but, as the human resource, also plays a vital role in its achievement. In the contemporary situation, four aspects of population in the less developed areas are operating to retard economic development. These are the relatively high rate of population growth, unfavorable age structure, unbalanced population distribution, and inadequately educated and trained manpower. All of these obstructions to economic development are amenable to control. But they cannot be controlled unless the ways in which they hamper efforts to raise levels of living are fully understood, relevant policies are formulated, and necessary programs put into operation. The relation between each of these population factors and economic development is briefly discussed in the materials which follow.

High Rates of Population Growth

2. The standard of living cannot be raised unless aggregate output increases more rapidly than total population. This relationship is shown in the following over-simplified equation: $L = \frac{O}{P}$, where "L" equals levels of living, "O" equals aggregate output and "P" equals population.[1] It is clear from this equation that an increase in aggregate output does not result in any increase in level of living if, simultaneously, there is a corresponding increase in total population. The greater the rate of population increase, then, the higher must be the rate of economic growth to effect any increase in per capita income.

3. The implications of this equation may be readily seen in examining the population and income data for the world, as a whole, and for its continental regions. During the second half of this century, according to the United Nations "medium" population projections, world population will increase about 2½-fold to reach a total of 6.3 billion by the year 2000 (table 1). Drawing also on the United Nations data for aggregate income for the world and its regions (table 2) the interrelationships between population increase and income increase may be ob-

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*UN conference paper.

Table 1. *Estimated population and population increases, by continent, 1900 to 2000*

Area	Population (million)					Av. annual increase (%)*			
	1900	1925	1950	1975	2000	1900–1925	1925–1950	1950–1975	1975–2000
World	1550	1907	2497	3828	6267	0.9	1.2	2.1	2.6
Africa	120	147	199	303	517	0.9	1.4	2.1	2.8
Northern America	81	126	168	240	312	2.2	1.3	1.7	1.2
Latin America	63	99	163	303	592	2.3	2.6	3.4	3.8
Asia	857	1020	1380	2210	3870	0.8	1.4	2.4	3.0
Europe (including U.S.S.R.)	423	505	574	751	947	0.8	0.6	1.2	1.0
Oceania	6	10	13	21	29	2.3	1.4	2.4	1.6

*Arithmetic mean of percentage of increase for 25-year periods.

Source: *The Future Growth of World Population*, United Nations, New York (1958).

Table 2. *Population and income, by continent, about 1950*

Area	Total population		Aggregate income		Per capita income ($)
	No. (thousands)	(%)	Dollars* (millions)	(%)	
World	2497	100.0	556	100.0	223
Africa	199	8.0	15	2.7	75
North America	219	8.8	241	43.3	1100
South America	112	4.5	19	3.4	170
Asia	1380	55.3	69	12.4	50
Europe (exclusive of U.S.S.R.)	393	15.7	149	26.8	380
U.S.S.R.	181	7.2	56	10.1	310
Oceania	13	0.5	7	1.3	560

*The calculations were made by using United Nations per capita income figures for each continent applied to revised United Nations estimates of 1950 population of continents to obtain revised aggregate income by continent and for the world. A new world per capita figure of $223 was obtained, as compared with the published figure of $230.

Source: *National and Per Capita Income of 70 Countries in 1949*, U.N. Statist. Papers, Ser. E, No. 1, United Nations, New York (1950).

served. For example, considering the world as a whole, aggregate income between 1950 and 2000, must be increased 4-fold to match the 1950 per capita income of Europe, and by 12-fold to match the 1950 per capita income of North America. A decrease in world population growth to 0.5 percent per year, the rate actually experienced between 1800 and 1850, would diminish the task of raising the aggregate product of goods and services by some 75 to 80 percent.

4. A similar analysis is possible by regions. Latin America, whose population is projected by the UN to increase more than 3½-fold during the second half of the century, would have to increase her aggregate product 8-fold to match the 1950 European level of living by the year 2000, and 23-fold to match the 1950 North American level of living. Africa, which may increase her population some 2½-fold during the second half of this century, would require a 13-fold increase in continental income to match the 1950 European level of living by the end of the century, and something like a 38-fold to match the North American level of living. Finally, Asia, which according to the United Nations projections may experience a population increase during the second half of this century as great as the population of the entire world in 1950, an increase of some 2.5 billion, would have to increase her aggregate income by a factor of 21 to match the 1950 European level of living by the year 2000, and by a factor of 62 to match the 1950 North American level of living by the same date.[2] Calculations of this type, over-simplified as they may be, nevertheless demonstrate that contemporary and projected rates of population increase in the economically less developed areas impose stupendous burdens upon them in their efforts to raise their living levels. Yet, ironically enough, there is an inverse relationship between the level of living of a region and its current and projected rate of population increase to the end of the century. (Compare tables 1 and 2.)

5. Rapid population growth also adversely affects investment to achieve economic growth. To effect an increase in output, investment increments must be great enough to produce income increments adequate to raise per capita income. Capital-income ratios indicate that to achieve an increment of one unit of income approximately three units of capital are required.[3] Populations increasing at a rate of 3 percent per year, already approximated by Latin America and other parts of the world and in prospect for most of the less developed areas in this century, must therefore achieve a savings of approximately 9 percent per annum, merely to maintain their present low levels of per capita income. Yet many of the economically less developed societies find it difficult to achieve a savings rate of more than 4 to 5 percent. It is doubtful that India, even with her prodigious efforts towards economic development, has as yet achieved a savings rate in excess of 10 percent. Thus, even with outside capital, she has been barely able to keep ahead of her 2 percent per annum increase in population.[4] This is why India has so much increased her effort to control population growth as an important factor in planning economic development.

6. Rapid population increase, however, is not necessarily a barrier to economic development. There can be little doubt that in the history of the present economically advanced nations rapid population growth may actually have contributed to increased product per head and to higher levels of living. But the man-resources ratio in the present economically advanced nations was, on the whole, much more favorable at their initial stages of economic growth than is true of the less developed areas today. In North America during the 19th century, for example, a resource-rich unexploited continent, rapid population increase undoubtedly contributed to increased levels of living. For with its low man-resources

ratio, rapid population growth contributed to economies of scale. In the less developed areas today where there is already a high man-resources ratio rapid population growth contributes not to economies of scale but to diminishing returns.[5]

7. Finally, it may be observed that rapid population increase serves as a barrier to economic development not only in the manner indicated above but, also, in the way it may contribute to an unfavorable age structure, to excessive urbanization, and to retardation of effective investment in human resources.

Unfavorable Age Structure

8. High fertility areas have larger proportions of young persons than do low fertility areas. (table 3) In Asia, Latin America and Africa in 1950, 40 percent or more of the total population was under 15 years of age. In contrast, in Europe and in North America, 26 and 27 percent of the total population, respectively, were under 15 years of age. By 1975, according to the United Nations "medium" projections, the age structures of the economically less developed, as compared with the economically advanced areas of the world, will not have appreciably changed. Because of their anticipated higher fertility rates they will still have larger proportions of their total population under 15 years of age.

9. The relatively large proportions of persons under 15 years of age in the high fertility, less developed regions of the world, may be interpreted as "unfavorable" to economic development for at least two reasons. First, the relatively high proportion of young persons below working age tends to reduce labor input per capita and, all other things being equal, tends therefore to reduce income per capita. Second, the larger proportion of young persons in the population requires that a greater part of limited resources be allocated to "social" investment

TABLE 3. *Estimated age composition of the population of the world and continents, 1950 and 1975*

Continent	Percent distribution					
	1950			1975		
	Under 15	15–59	60 & Over	Under 15	15–59	60 & Over
World	37	56	7	38	54	8
Africa	42	54	4	41	54	5
Northern America	27	61	12	28	56	16
Latin America	40	54	6	42	52	6
Asia	40	55	5	41	54	5
Europe	26	62	12	24	59	17
Oceania	30	59	11	31	55	14
U.S.S.R.	33	59	8	30	59	11

Source: United Nations, *The Future Growth of World Population*, United Nations, New York, p. 35 (1958).

rather than to "economic" investment. That is, the more youthful the population the greater is the proportion of total savings that must be devoted to the rearing of the young, and the smaller is the proportion of total savings that is available for investment in agricultural or industrial projects designed to increase per capita production.

10. The adverse effects on economic development of the age structure of a high fertility society may be readily documented. Changes in age structure are the result of changes in fertility and mortality. Reductions in the death rate occur first of all and disproportionately among infants and youth. In consequence, reduced mortality tends to increase greatly the proportions of young persons in a population. On the contrary, reductions in the birth rate tend to decrease the proportion of young persons in a population. Over time, a population ages more rapidly by reason of a reduced birth rate than as the result of a decreased death rate.[6] The effect of reductions in fertility and mortality on the proportion of workers in a population and on "needs" per worker resulting from changes in age structure are presented in table 4.

11. It may be observed that as mortality decreases, while fertility remains constant, there is a decrease in the proportion of "active" males, that is workers,

TABLE 4. *Estimated active males per 1000 population and estimated needs per 1000 active males at different levels of expectation of life at birth and of gross reproduction rate*

Activity rates in less developed countries*

Gross reproduction rate	Expectation of life at birth		
	30 years	50 years	70 years
	Active males per 1000 population		
4.0	255	240	226
3.0	286	271	257
2.0	328	315	301
1.0	392	382	369
	Needs** per 1000 active males		
4.0	3,323	3,489	3,672
3.0	3,016	3,146	3,288
2.0	2,699	2,766	2,870
1.0	2,283	2,309	2,373

*For effects assuming developed countries activity rates, see source.
**Needs of one adult = 1.0.

Source: U.N. Population Studies, No. 26, *The Aging of Populations and Its Economic and Social Implications*, United Nations, New York, p. 62 (1956).

in a population. For example, if the gross reproduction rate remains at a level of 3.0, the number of active males per 1000 population decreases from 286 when expectation of life at birth is 30 years, to 257 when expectation of life reaches 70 years, a decrease of 10 percent in the proportion of workers in a population. In contrast, as the birth rate declines while the death rate remains constant, an increase in the proportion of workers takes place. Thus, when expectation of life at birth is 30 years, a decline in reproduction rate from a level of 4.0 to 2.0 results in an increase in active males per 1000 population from 255 to 328, an increase of almost 30 percent. The joint effect of decreasing mortality and decreasing fertility may also be measured. A death rate that has decreased to achieve an expectation of life of 50 years from a level of 30 years while the gross reproduction rate declines from 4.0 to 2.0, effects an increase in active males per 1000 population from 255 to 315, an increase of almost 25 percent.

12. Since many of the less developed areas of the world are in the process of achieving an increase in expectation of life at birth from approximately 30 years to 50 years, the entries under these two levels of expectation of life in table 4 point to what may be the actual experience of such areas if reductions in fertility are effected.

13. The "needs" of a population are to some extent a function of its age structure; that is, consumption varies with age, for both children and elderly people have different needs from those of adults of intermediate age. The United Nations has estimated the changes in the needs of a population with changing age structure, expressing the needs of an adult as unity, 1.0, and the needs of a child or an aged person by 0.7 of a unit. The changing needs per 1000 active males in the population under the impact of changing fertility and mortality are shown in the lower panel of table 4.

14. It is readily seen that as the death rate declines and expectation of life at birth increases, needs per 1000 active males increase. Thus, with a gross reproduction rate of 4.0, needs per 1000 active males would rise from 3,323 units to 3,672 units as expectation of life increases from 30 years to 70 years, an increase of over 10 percent. Contrariwise, a decrease in the birth rate while mortality remains constant has the effect of decreasing needs per 1000 active males. Thus, if expectation of life remains fixed at 30 years a decline in the gross reproduction rate from 4.0 to 2.0 would reduce needs per 1000 active males from 3,323 units to 2,699 units, or by almost a fifth. The joint effect of decreasing fertility and mortality may also be traced. Thus, if a gross reproduction rate declines from 4.0 to 2.0 while expectation of life increases from 30 years to 50 years, needs per 1000 active males decline from 3,323 units to 2,766 units, a decrease of about 17 percent. A decrease in the birth rate brings about a decrease in the needs of a population per 1000 workers as the net effect of an increase in the proportion of workers and of a decrease in young persons below working age.

15. The decline in the proportion of young persons contributes to economic development in still another significant way. For the smaller the proportion of persons below working age, the smaller is the proportion of total savings that must be allocated to the rearing of the young, and the greater is the proportion of total savings that may be allocated to productive investment. Hence, a decrease

in the proportion of persons below working age simultaneously decreases the dependency burdens of workers and increases the proportion of total savings which may be placed in productive channels.

16. High fertility, then, under conditions of declining mortality, has the effect of retarding economic development not only in being responsible for high rates of total population growth but, also, in producing an age structure which adversely affects economic growth.

Imbalance in Population Distribution

17. High urbanization generally is identified with economically advanced areas and the advent of industrialization. Yet despite their relatively low rate of industrialization, the less advanced areas in Asia, Latin America and Africa, because they have such a vast total population, have more people living in cities of 20,000 or more, or cities of 100,000 or more, than do the economically advanced nations of Europe and North America combined. In 1950, Asia, Latin America and Africa, contained over 45 percent of the world's residents of cities of 20,000 or more; whereas, Europe (excluding the USSR) and North America contained but 41 percent of the world population living in cities of this size.[7] (See table 5) Moreover, during the 20th century the rate of urbanization of Asia, Latin America and Africa has exceeded that of Europe and North America.

18. The degree of urbanization has quite different implications for economic development in the advanced than in the less developed areas. In the economically advanced nations, urbanization is both an antecedent and a consequent of high levels of living. It makes possible and advances the division of labor and specialization, the application of non-human energy to production, improved technology, economies of scale, external economies, minimization of the frictions of space and communication, and, in general, higher per capita income. In the economically less developed areas, how-

TABLE 5. *Distribution of urban population of the world, by continents, 1950*

Continent	Total population %	Population living in cities of 20,000 and more %	Population living in cities of 100,000 and more %
World	100	100	100
Asia	53.2	33.8	33.7
Europe	16.4	27.5	26.5
North America	6.8	13.9	15.2
U.S.S.R.	8.1	12.0	11.2
South America	4.6	5.8	6.5
Africa	8.2	3.7	3.2
Central America	2.1	2.1	2.0
Oceania	0.5	1.2	1.6

Source: Philip M. Hauser (ed.), *Urbanization in Asia and the Far East*, UNESCO, Calcutta, p. 99 (1957).

ever, urbanization tends to be the product of quite different factors and is not accompanied by corresponding increases in productivity and levels of living. In the less developed areas of the world today, urbanization is less the result of indigenous economic development and more the product of economic development of an historical imperial system focused largely on a "mother" country. Urban agglomerations in the less developed areas are more the product of the push of population from over-populated rural areas than the pull of population to urban centers by reason of greater economic opportunity. Furthermore, the recent acceleration in the rate of urbanization in many of the less developed areas reflects the disruption and disorganization produced by the war and post-war political instability creating a troubled countryside and large refugee populations. By reason of the above considerations, the less developed areas of the world may be said to be "over-urbanized" in the sense that larger proportions of their population live in urban places than is justified by their degree of economic development. More specifically, compared with the economically advanced nations at comparable levels of urbanization, a much smaller proportion of the labor force in the less developed areas is engaged in nonagricultural and especially mechanized industrial occupations.

19. In consequence, the relatively large urban populations in the less developed areas serve as a barrier rather than as an accelerant to economic development. To state that a less developed area is over-urbanized is to pose its major economic problem because what is meant is that it does not have an adequate economic base to support its urban population by the standards of the economically advanced nations. Such areas are faced with the problem of achieving higher levels of economic devolpment to support their present, let alone their prospective urban populations. The accelerating rates of urbanization which confront the less developed areas are likely to worsen rather than to ameliorate their poverty and distress. Asia, for example, is faced with the prospect of tripling her urban population in the quarter of a century between 1950 and 1975, assuming the population increase that is projected by the United Nations and the continuation of her 20th century rate of urbanization;[8] and the prospects for Latin America and Africa are approximately the same. The fundamental economic problem of the less developed areas is that of achieving increased productivity. The many difficulties which obstruct the attainment of this objective are likely to be exacerbated rather than ameliorated by the present and prospective rates or urbanization.

20. Given the present levels of productivity and limited savings in the less developed areas, a major common problem relates to the allocation of resources for the improvement of agriculture, on the one hand, and the development of industrial sectors of the economy, on the other. In many nations improvement in the productivity of the agricultural sector of the economy may contribute more to rising levels of living than efforts to induce industrialization. The claims of large and growing urban populations and their growing political importance may require disproportionate allocations of limited resources to the development of the urban, rather than the agricultural, sectors of the economy, at the expense of a net increase in product per head.

21. The achievement of adequate balance between agricultural and urban in-

dustrial development is complicated by difficult problems of dividing limited savings between "social" and "productive" investment. This problem, although it is manifest both in the urban and in the rural sectors, finds its most acute form in the city. Urban areas in the less developed nations are characterized by inadequate infra-structure development which precludes the usual amenities of urban existence found in advanced nations. There is a great need and much temptation to allocate resources to social purposes such as the elimination of shanty towns, piped water, sewerage, better housing and social services for immigrants. Social investment of this type, badly needed as it may be can be made only at the expense of decreased investment in agricultural and industrial productive facilities—investment designed to increase productivity as in tractors and fertilizers or in power plants, factories and transport.

22. The already acute problems of the urban areas in the less developed areas, social and political, as well as economic, are intensified by the large internal migratory flows of population from rural to urban areas. This fact has been recognized by a number of nations which are making efforts to decelerate rural to urban migration by means of programs designed to raise levels of living of the rural population. It may well be that the quickest way to increase the levels of living of urban population may lie in agrarian reforms, including modification of outmoded land tenure systems, which would give the agricultural population a stake in the land, produce higher productivity, and induce the rural population to remain in rural areas.

23. Imbalance in the distribution of population between urban and rural areas, considered in relation to industrial and general economic development, may, then, operate to retard economic growth. Needless to say, such a maldistribution of population is worsened by excessively high rates of total population increase. The dampening of total population growth rates would undoubtedly bring about a sharp decline in the rate of urbanization and make a more balanced population distribution possible.

Quality of Human Resources

24. The three aspects of population which tend to retard economic development discussed above are each concerned with problems of quantity of population—total population, an unfavorable age structure, and imbalance in urban-rural distribution. Also operating as a barrier to economic development, is the low quality of population in the less developed areas, that is, the low general educational level and low skill of the population and most importantly of the labor force. High levels of illiteracy and the absence of a skilled labor force serve as major barriers to economic growth, particularly in the urban and industrial sectors of the economy.

25. It is becoming recognized that perhaps the most important single type of investment for achieving economic development is investment in human resources. In fact it is being argued that "investment in the human factor may well have a higher payoff in terms of increased output than does any other input".[9] Moreover, evidence is mounting that only a relatively small share of increased output is the result of increases in the conventionally regarded inputs of labor, land and capital combined. For example, recent studies suggest that for the period

1899–1953 in the United States, only a third of increased output may be accounted for by increased input of labor, land and capital. The remaining two-thirds of the increase in output seems to be the result of the combination of technology, organization, and human capital together with all other factors.[10] Moreover, the data suggest that of these latter four types of input, human capital may be the most important. Investment in human resources is essentially investment in the improved quality of population, as it may be achieved through increased education and training.

26. There is little need for elaborating the importance of increasing the level of education of a population as an important element in achieving economic development. A major barrier to raising the educational level of a nation, however, may be found in high fertility. This can be readily demonstrated. (table 6) It is apparent that as mortality decreases while the birth rate remains fixed, total school construction needs may increase from a doubling to more than a quadrupling. Thus, with a gross reproduction rate of 3.0 an increase in expectation of life from 30 years to 70 years, would result in a 2½-fold increase in school construction needs, an increase from 10 units to 25 units. Contrariwise, a decrease in birth rate produces a substantial decrease in school construction needs when mortality is held constant. Thus, for an expectation of life of 50 years, a decrease of more than two-thirds is effected in school construction needs when the gross reproduction rate declines from 4.0 to 2.0. That is, annual school construction needs declines from 29 to 8 units. If the birth rate is decreased along with declines in the death rate, appreciable decreases in school construction needs may be effected. For example, if the gross reproduction rate is decreased from 4.0 to 2.0 while expectation of life increases from 30 to 50 years, school construction needs are de-

Table 6. *Estimate of total annual school construction needs per 1,000 active males at different mortality and fertility levels**

Activity rates in less developed countries**

Gross reproduction rate	Expectation of life at birth		
	30 years	50 years	70 years
4.0	19	29	38
3.0	10	19	25
2.0	***3	8	13

*Construction required for one male pupil = 1.0

**"It has been assumed that, between the ages of 10 and 24, school attendance rates were equal to the difference between the male activity rates and 1 in the five-year age groups and that all children of from five to nine years of age attended school."

***The difference between the rate of replacement needs (2.9 per 1,000) and the rate of vacancies occurring.

Source: U.N. Population Studies, No. 26, *The Aging of Populations and Its Economic and Social Implications*, United Nations, New York, 1956, p. 69.

creased by more than 50 percent—from 19 to 8 units.

27. The gains that may be achieved from a reduction in birth rate in decreasing the investment necessary for educational construction may, of course, also be gained in decreasing the investment necessary for increasing teachers and educational facilities. Similar savings may be achieved on training programs, that is, the teaching of occupational skills.

Concluding Observations

28. Economic development policies and programs must take into account the role of population factors, in general, and specifically the four aspects of population which have been discussed above. To eliminate the adverse effects of population factors on economic development it is necessary to dampen rates of total population increase, to effect a more favorable age structure, to achieve a more balanced urban-rural population distribution, and to raise the quality of the population by attaining higher levels of education and training. Each of these goals is attainable, and, significantly enough, all may be achieved by the same means—namely, through a decrease in the birth rate.

29. In the contemporary world situation, given the great declines in mortality achieved and in prospect, a decrease in the birth rate would simultaneously reduce rates of population increase, favorably alter the age structure, help to effect better balance between urban and rural population distribution, and permit more adequate and effective investment in human resources.

30. A decrease in birth rate seems a simple enough solution. But it is not easy of attainment. The hard fact is that in most of the less developed areas there is neither incentive nor motivation for regulating family size. Moreover, it is not clear that the techniques for controlling fertility are as yet available which can be effectively employed in these areas. In the contemporary world there are no economically advanced nations which do not employ both death control and birth control. But, there is no guarantee that the methods that have proved to be effective in the economically advanced areas will automatically prove to be effective in the less developed areas.

31. There is a great need, therefore, for increased research both in the social sciences and in the natural sciences. Social science research is needed to learn more about how to increase motivation and incentive for the regulation of the family size. Natural science research is needed to learn more about human reproduction so that more effective methods for controlling fertility may be developed. Programs for the development and application of science and technology for the benefit of the less developed areas must necessarily embrace these needs.

FOOTNOTES

[1] For fuller discussion of relation of population growth to economic development see: United Nations, *The Determinants and Consequences of Population Trends,* United Nations, New York, 1953, especially Part III, 181–288; Lewis, W. Arthur, *The Theory of Economic Growth,* Richard D. Irwin, Inc., Homewood, Illinois, 1955, Chapter VI, especially 304–330; Kuznets, Simon, *Quantitative aspects of the economic growth of nations: I, levels and variability of rates of growth,* Eco-

nomic Development and Cultural Change, *5*, 1, October, 1956, 5–94; Coale, Ansley J. and Hoover, Edgar M., *Population Growth and Economic Development in Low Income Countries,* Princeton, N.J., Princeton University Press, 1958, especially Part Four.

[2] Hauser, P. M., *Population Perspectives,* Rutgers University Press, New Brunswick, New Jersey, 16–20, (1960).

[3] United Nations, op. cit., pp. 277 ff. Also Ward, Barbara, *The Rich Nations and The Poor Nations,* W. W. Norton and Company, Inc., New York, 1962, p. 91. Kuznets, Simon, *Quantitative Aspects of the Economic Growth of Nations: V, Capital Formation Proportions: International Comparisons for Recent Years,* loc. cit., *8*, 4, Part II, July 1960, 1–96; and *VI, Long Term Trends in Capital Formation Proportions,* loc. cit., *9*, 4, Part II, 3–124, July 1961.

[4] Ward, B., op. cit., p. 92.

[5] Lewis, W. A., op. cit., pp. 323 ff.; also PEP, *World Population and Resources,* Political and Economic Planning, London, 1955, pp. 90 ff. and also Part II, Chapter 4.

[6] United Nations, *The Aging of Populations and Its Economic and Social Implications,* United Nations, Chapter II. (New York, 1956).

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Manpower Projections and Techniques

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1. The development of national economic goals must take into consideration the future availability of manpower in adequate amounts, and possessing required skills and education. This is true for highly developed industrial nations as well as for the developing nations of the world.

2. The purpose of this paper is to describe some of the techniques utilized in the preparation of projections of manpower requirements and resources in the United States and to discuss briefly their application to developing nations.

3. The United States has a dynamic economy—growing and changing at a remarkable pace. Population and labor force growth have been rapid, and changes in technology and the pattern of demand have resulted in revolutionary shifts in the structure of employment in recent decades. Such industries as trade and service and State and local governments have grown at a rapid pace; some industries, including the manufacturing complex, have shown little or no growth; and some, such as agriculture and mining, have curtailed employment sharply in a relatively few years.

4. These rapid changes have made it essential to develop techniques which will permit us to anticipate future needs for workers, especially highly trained professional, technical, scientific, and skilled workers, with the aims of avoiding shortages that will hamper economic growth on the one hand, and structural unemployment on the other.

5. In many respects, therefore, the United States faces many of the same problems in the field of manpower that affect other nations which are undergoing periods of rapid technological change, including developing nations.

Estimating Manpower Requirements

6. A major factor in determining the manpower requirements in most industries is the level of industrial activity in that sector, which in turn is related to the overall level of economic activity for the nation and the pattern of that activity. The requirements for manpower in specific occupations, therefore, are a function in part of the level and structure of gross national product. A model of the economy projecting the level and composition of output is, then, the starting point for projections of manpower requirements.

7. Two broad approaches to the projection of overall demand customarily have been utilized as a first step in projecting manpower requirements.

(a) One approach assumes that a given level (or alternative levels) of output will be achieved in a target period. It can either represent a desired level of income and consumption or be the result of an assumed rate(s) of growth of the economy. This projected level of output can be estimated by fairly sophisticated analysis of trends in consumer expenditures, business investment, and government demand or it can be merely the result of the projection of given rates of growth of the private or total economy. This general approach has the advantage of making it possible to examine the manpower implications of different assumptions of rates of growth of the economy.

(b) Another approach is to stipulate full employment in a target period and then examine the implications for manpower requirements and resources of the economy at that time. This approach, most frequently used in manpower projections in the United States, begins with a projection of the supply of labor—the labor force. This may be reduced to employment totals by the deduction of the unemployment estimated to exist under conditions of full employment. When coupled with projections of the length of the work year (adjusted for changes in hours worked, vacations, holidays and other time-off), and of productivity for the total private labor force, the estimates of overall employment can then be used to determine levels of output for given future periods.

8. An evaluation of population trends is a critical first step in projecting labor force, since the number of persons available for work depends largely on the population of working age at any given time. As a basis for an adequate population projection it is necessary to have figures on population by age and sex, and information on births, deaths, and in and out migration. Population projections are generally made by applying survival rates to the population plus annual estimates of births and the net effect of migration. The survival estimates, of course, must include an allowance for any trend in mortality rates. Projecting the number of births is also a major problem, since there may be substantial changes in the fertility rate during relatively short periods, especially in a nation undergoing significant social or economic changes.

9. To compute projections of the labor force from estimates of the population, it is then necessary to evaluate and project trends in the proportion of the population participating in the labor market. Where data for current and past periods are available, projections are made by detailed age-sex categories, because of substantial differences among groups in their participation in the labor force (1). Generally, most adult men are in the labor force, but there can be significant changes in the rates of participation of youngsters, older persons, and married women. This has been dramatically evident in the United States in recent years, when there has been a sharp decline in the labor force participation of school-age youth and men of retirement age, and a sharp rise in participation of married women whose children have reached school age. Sharp changes in labor force participation should certainly also be anticipated in an economy in a phase of rapid development from an agrarian to an industrial nation. As a basis for projecting participation rates in developing nations where little labor force data may be available, it may be valuable to view the pattern of changes that have occurred in other economies as they have moved progressively through the phases of industrialization.

Industrial Employment Requirements

10. When the general overall levels of economic activity and employment have been estimated for some future period, further analysis of labor requirements and supply is needed to provide an industrial and occupational distribution of the employed total.

11. Labor requirements are generally harder to estimate than is the supply of labor. The supply is significantly related to demographic variables which are less likely to produce drastic shifts in the number of persons expected to be seeking work in short periods. In the United States, for example, since the labor force is defined to include persons 14 years of age and over, entrants for the next decade are already living. Of course, as explained previously, other variables such as participation rates and retirement and death rates must be estimated to complete the supply projections.

12. However, the complex relations which exist between the overall level of economic activity and the requirements of the subordinate components which dictate the number and kinds of jobs necessary to produce the total of goods and services, make estimates of labor requirements much more subject to error. In a nation like the United States, which has an economy not only relatively highly developed, but also one which comprises large areas of economic voluntarism by consumers and producers alike, estimates of future numbers and types of industrial labor requirements are extremely difficult to develop.

13. Among the factors affecting the need for labor in specific industries are the amount of domestic production of individual goods and services, and the changes in manpower estimated to be needed for such production. In turn, the amount of production of specific goods and services related to an overall estimate of total national output depends on a host of factors affecting final demand.

14. Industrial manpower requirements will also vary in accordance with changes in output per man-year in each industry. These changes reflect the complex of circumstances affecting worker productivity and hours worked. The latter reflect long-term trends in shortened workweeks—the effects of legislation and voluntary agreements between management and workers.

15. The specific factors represented by all these considerations are many and complex. In practice, it would be virtually impossible for a procedure to recognize even a portion of them explicitly for more than a small part of the economy. Therefore, as a matter of practical necessity, analysts in the United States have been compelled to seek simpler procedures for most segments, reserving more elaborate treatment for the segments which are important enough and for which sufficient data are available to warrant special efforts.

16. In general, three types of approaches have been employed in the Department of Labor in relating estimates of total economic activity to individual industries. They are:

(a) Relation of employment in individual industries to projected total employment for all industries.

(b) Relation of production in each industry to total projected production, and subsequent translation of projected industry production into estimates of industry employment.

(c) Allocation of total production among the various goods and services by a complex system of interindustry relationships, thereby developing estimates of industry production and employment. This has been used on only a few occasions, and is still in process of further development (2). When finally developed it will represent the most sophisticated approach to the determination of future economic and manpower requirements yet perfected for the United States.

17. All the procedures discussed are based on past data and reflect past relationships. To make any of them responsive to changes in the future which have not developed from past trends, it is necessary to recognize the possibility of changes in technology and in the uses of materials which would change in substantive fashion the character of the relationships used in estimating.

Approaches to Projecting Industry Employment

18. *Relation of employment in individual industries to total employment.* This approach, the simplest to calculate, assumes that the movement of employment in certain individual industries varies characteristically with the fluctuation of total employment. By estimating the level of employment directly from projected total employment, the intermediate step of calculating individual industry production totals is not required.

19. While this method would appear to be almost too simple to produce useful and meaningful results, it has been found that in many industries the movement of employment has in fact varied in sufficiently characteristic fashion in relation to total employment to make the procedure a useful tool. Regression equations are first calculated between private nonagricultural employment and employment in each of the broad industry divisions: manufacturing, mining, construction, trade, services, and finance. Employment in agriculture and government, whose levels are determined in large measure independently of levels of national employment, are projected separately. The correlation procedure is then repeated for smaller aggregates of individual industries relative to their broad industry divisions.

20. Although having the advantage of simplicity, this method requires data for a number of previous years in order to permit the calculation of meaningful regression equations. In addition, it is a mechanistic approach whose validity becomes weak for long-range projections well beyond the span of years covered by the data. And since it is based on past experience, new factors involving technological changes in the industry or shifts in the demand for products of individual industries relative to the total economy, could make determinations based on the method misleading. However, as a first approximation, and subject to adjustment of the results by data derived from special studies of specific industry employment trends, this method provides useful results.

21. *Projection of production in each industry in relation to projected production, and subsequent translation of industry production projections into employment.* This approach, also involving correlation analysis, is based on the relation between the production of individual industries with total projected production. This is done, as in the previous method, for the broad industry divisions first and progressively for smaller industry aggregates related to the broad industry division totals. This procedure, while

still essentially mechanistic, permits greater numbers of checks for internal consistency. For example, some comparisons can be made to ascertain that the data on projected production of certain goods and services are consistent with the projections of output of end-products in which they are used. Other similar checks are possible. If the original calculations appear to give distorted results, corrections can be made before the translation of products to employment is made. Further analysis at this stage includes detailed studies of each industry's future product demands and technological trends, as far as they can be ascertained. The method permits the inclusion of fairly sophisticated internal consistency review procedures, but it is not a self-checking operation and much is dependent on the ingenuity and judgment of the analyst for meaningful results.

22. In the subsequent step, that of translating production estimates into employment estimates for individual industries, consideration must be given to output per man-hour, average hours worked per worker and expected changes in their trends.

23. This procedure has the advantage of providing data which can also be used for economic analyses in areas other than manpower. However, its statistical data requirements are more demanding. In addition to employment data, information on production, price indexes, and hours of work by appropriate industry classification are necessary.

24. *Allocation of total production among various industries by use of interindustry coefficients.* This procedure relates the flows of materials between industries and is the most complex and sophisticated yet undertaken for the development of projections of the economy of the United States. It requires economic and technical data covering the entire economy in a comprehensive yet exceedingly detailed manner. In order for this procedure to produce meaningful results, data concerning intermediate as well as final demands on the economy must be developed. Analyses of the American economy utilizing input-output techniques have been done in the past in varying degrees of industrial detail. Currently work in this method has again been undertaken to provide projections of the economy for periods of 5 and 10 years in the future, for a wide variety of purposes.

25. This technique, once the basic data are available in the form required, permits the examination of the effects of varying assumptions on future trends in the economy. For example, assumptions can be made of high or low productivity, high or low investment programs, and high or low defense expenditures.

26. It should be noted that while each of the procedures described above for projecting manpower requirements may be useful in highlighting some of the problems involved in achieving full employment, the projections cannot by themselves forecast whether or not full employment will in fact be achieved. It is also important to note that each of these methods is vulnerable to the need for judgment in areas of future changes in productivity and in shifts in the relations of demand for products. The interindustry relations method does, however, relate existing knowledge and assumed changes in a more rational fashion than does any other type of analysis. It also has the unique feature of being virtually self-checking with respect to internal consistency. However, the development of an interindustry matrix requires vast pro-

cessing of detailed production and shipments data.

Projections of Industry Employment by Occupation

27. Projections of industry employment by occupation were developed by the Bureau of Labor Statistics through the use of an occupational-industry matrix which, for some 150 industries comprising the total economy, presents the absolute and relative distribution of employment in about 150 occupations. The basic matrix represents the occupational distribution of each of the industries in the economy as of a specific period of time and requires detailed statistics on occupations by industrial distribution normally available only from a comprehensive census. It is by itself a major undertaking.

28. In the application of the occupational-industry matrix for the projection of manpower requirements, it should be recognized that changes in the future occupational composition of industrial work forces must be projected in order to correct for shifts in productivity and in job functions related to changing technology. The unique advantage of working with the matrix, as modified to reflect these changes, is that it distributes the entire projected labor force by occupation and industry and provides the framework for occupational estimates consistent with overall projected industry and economy-wide totals.

29. The matrix was prepared in relatively detailed fashion for the United States; it would be useful because of the controls it exercises on the product totals even if it incorporated much broader industry sectors and less occupational detail.

30. An example of the type of occupational requirements study useful for the modification of matrix relationships or other projection techniques, is a recent study undertaken in the Department of Labor. This study, *The Long-Range Demand for Scientific and Technical Personnel,* prepared by the Bureau of Labor Statistics for the National Science Foundation in 1961, was an effort to assess the need for scientists and engineers in the United States for the year 1970. In selecting the methodology, a major effort was made to examine the relationships of scientific and technical employment with other economic indicators capable of being used for projection purposes. It was found from a study of the trends of past data that the most significant relationship was that between the number of scientific and technical personnel in an industry and total employment in that industry for recent years.

31. The use of a regression relationship technique was generally supported by detailed investigation of the demand for scientists and engineers in two major industries, chemicals and electrical equipment, although some adjustments were necessary. Special studies were also conducted for other industries and occupations, where data were not adequate to support the use of the regression technique.

Occupational Supply

32. After occupational requirements have been determined, estimates must be made of the availability of workers to meet these requirements. The first step is the determination of the current supply of workers by occupation. Secondly, estimates must be prepared of the additions to and withdrawals from each occupational group over time. These estimates must then be matched against the

projected occupational requirements so that areas of potential shortages and dislocations may be pinpointed.

33. The enumeration of the steps involved is somewhat easier than their solution because of the lack of detailed data, especially by occupation, for many sectors. In addition, other factors such as the transferability of skills among occupations, and changing labor force participation rates, are important background elements affecting occupational supply. Transferability, for example, is easily accomplished among relatively unskilled occupations, but even at higher levels, including the professional, there is some shifting among fields of discipline. Consequently, when earnings or employment opportunities are relatively high in an occupation, those in other occupations or out of the labor force may be induced to shift. Therefore, the potential supply for an occupation is, except for some where shortages exist, generally greater than the number of people currently working in that occupation.

34. The basic source of occupational data in the United States is the decennial Census of Population. This source provides information on several hundred occupational categories. The Monthly Report *on the Labor Force* of the U.S. Department of Labor, which is based on a monthly sample survey of the noninstitutional population, is the source of current data for the dozen broad occupational groups in our classification system, e.g., professional and technical workers, clerical, sales, craftsmen and foremen, operatives, nonfarm laborers, etc. Data for some selected breakdowns within the groups are also provided.

35. For those occupations where formal training is required, estimates of additions to the work force may be prepared from various sources. Data are most readily available for the professional occupations and the skilled crafts where institutional requirements must be met—i.e., degrees, licenses, and certificates—before the student or trainee is considered fully qualified. In these cases, data may be obtained from educational institutions, training facilities or licensing authorities. Secondary vocational schools and organization membership rosters are also sources of information.

36. In addition to providing statistics on the numbers of persons who have completed training in various fields, some information is generally available from educational institutions or apprenticeship training facilities on the numbers currently enrolled in certain prescribed areas, providing the basis for short-term projections. The data on enrollees registered in each year must, however, be modified by some estimate of the rate of drop-outs, since it is a dictum that not all students or trainees who begin a particular long-term course of study will graduate from that course. They may drop out of school altogether, or they may shift to another field.

37. Formal training courses, however, are not a complete source of data on the numbers of persons entering the skilled crafts or even some of the professions. In some cases, persons who had dropped out of courses before completion have been able to supplement their education with experience, and in time become qualified and accepted members of their craft or profession. In addition, many persons have completed on-the-job training in establishments, or in the Armed Forces, or in informal apprenticeship programs (not formally registered with the U.S. Department of Labor's Bureau of Apprenticeship). Estimates of the occu-

pational supply stemming from noninstitutional sources have in many cases been based on sample surveys of personnel in employing establishments, requesting information on their education and experience which is pertinent to their current occupations.

38. Long-term projections of the supply in professional occupations may be made with some semblance of precision for college graduates, but for other groups, unfortunately, even imprecise data are generally not available. Projections of graduates by field of discipline are based on estimates of college enrollment applied to projections of the population by age and sex.

39. It is anticipated that research programs undertaken by the Office of Manpower, Automation and Training of the Department of Labor will develop data on numbers of persons obtaining training from various sources, including the Armed Forces, correspondence schools, unofficial on-the-job training programs and other noninstitutional sources.

40. In addition to the preparation of estimates on the numbers entering specific occupations, estimates must also be made of withdrawals from each occupation. Persons who die or retire must be replaced, as must those who leave the labor force or who transfer to other fields. Estimates of losses due to death and retirement are more easily made than estimates due to other reasons.

41. Attrition due to death may be estimated by the use of standard life mortality tables. Generally, it has been assumed that the age composition of the occupation is similar to the age distribution of the adult population. Retirement estimates for specific periods are then based on the age estimates coupled with an assumed retirement age, after allowances for death.

42. Tables of working life developed by the United States Department of Labor are an efficient device for measuring withdrawals from an occupation. These tables show, for successive ages, losses due not only to mortality but also to retirement. Separate tables of working life are available for men and for women (3). Those for women also take into account withdrawals from the labor force and reentry associated with marital status and childrearing.

43. Practically the only data available on transfers to other occupational fields stem from selected sample studies of work histories collected from individuals. These studies, however, are too fragmentary for broad use, and much work remains to be done in this area.

44. After data on entrances and exits from specific occupational fields have been prepared, the gross projections by occupation are adjusted by these estimates. These data provide the basis for a comparison with future occupational requirements and reveal those areas where supply and demand are not in balance.

45. Attention must be given to areas of potential imbalance. The early direction of vocational guidance toward expected fields of shortages can do much to circumvent those shortages, especially in areas where relatively long-term courses of study are necessary. Therefore, vocational advisors must be educated in the field of occupational outlook, with particular emphasis given to occupations where the demand is expected to exceed the available supply. In addition, educational and training facilities of the kinds needed must be available, staffed and supported, to ensure an adequate reservoir of

skilled and trained manpower for future needs.

Application and Modifications of Projection Techniques for Developing Nations

46. The procedures employed for estimating manpower requirements in the United States require fundamental modifications when applied to the same purposes in developing nations (4). Nonetheless, there are useful elements applicable with differing degrees of emphasis.

47. In selecting the applicable procedures, it is useful to recognize with candor differences in the political and economic framework which do not permit the exact duplication of American procedures. In a highly developed industrial economy undergoing no radical change in the structure of society or political orientation, it is feasible to project manpower requirements by extrapolating past trends. This assumes an orderly continuation of an ongoing process of economic development subject to specific direction largely only in limited sectors such as national defense and public service. Growth is projected from a highly developed industrial base, with a literate, basically skilled and expanding population, and with a supply of capital available for industrial expansion. The capabilities are present in the existing framework both for growth and for change; past trends have demonstrated precisely such potentials for expansion and for transformation in the industrial and occupational framework.

48. In a developing economy, where previous growth would not be acceptable as a standard for future development, the projection of manpower requirements is in practice contingent on the magnitude and nature of the economic goals established beforehand, and is actively linked with a current process of economic planning and control.

49. Where economic goals call for the establishment of industries which do not as yet exist, or where they call for the extension of industries uniquely situated (for example, industries established and operated by foreign personnel), then, obviously, it is not feasible to project manpower requirements on the basis of previous trends or by such methods as soliciting requirements from employers. Moreover, in practice, often very little of the data required even to define past trends or the current situation are available.

50. In many cases, data from other countries can be more useful than data for the subject country. This would be true, for example, in developing occupational requirements for projected industry levels where the industry does not yet exist in its projected form. Moreover, where the existing industry in the developing nation is small, its occupational structure may be quite different from the industry at its projected level. On the other hand, the occupational distribution at the projected level may be similar to that in some more developed nation at the current or some previous stage. The Puerto Rican example has direct bearing on this adaptive procedure. In the 1957 projection of Puerto Rico's manpower needs for the year 1975, it was assumed, on the basis of a projection of previous trends, that the productivity and occupational mix of most sectors would be the same in Puerto Rico in 1975 as in the United States in 1950. This provided a basis for determining the number and kinds of specific skills needed to achieve the industry pattern projected for 1975.

51. In some ways, the evaluation of manpower requirements in developing economies is somewhat easier than for advanced economies, in that guidelines to the future structure of occupation and industry employment are available in the present pattern and history of development of the more advanced economies. Similar bases for comparison are not readily available for projecting manpower requirements in advanced nations. However, this technique is utilized to some extent by studying the structure of the most advanced firms and industries as an indicator of the future path of development for the rest of the economy.

52. In addition, it is possible for developing nations to import skilled labor to fill critical occupational needs, and to use these workers as a cadre for training manpower.

53. Obviously, the Puerto Rican application cannot be precisely paralleled by all countries, but the same projection methods can be applied with modifications based on differences in skill level and productive capacity of the available manpower supply, and on judgmental considerations involving the effect of social and political factors on the occupational framework, e.g., the length of the workweek and workday, and observances of national or religious customs which influence occupational needs.

54. The value of the projections is that work can then proceed on the development of manpower supply through programs of education and training. Where shifts in technological processes are encountered—and they should be anticipated—a system of retraining and upgrading, even of skilled workers, must be provided for. Such retraining, as well as the development of information required to formulate manpower policy, are now provided in the United States in the Manpower Development and Training Act administered by the Department of Labor.

55. Part of the projection of manpower needs must include provision for teachers and training personnel. Part of the economic goals must also include an allocation of resources for schools and training equipment. The projections provide a basis for getting on with the work in orderly fashion.

56. Although experience usually will dictate certain modifications during the period of economic development, the availability of a system of projections provides a standard for measuring performance and a guide for action; such projections should contribute to a substantial gain in time and a savings in resources for any nation anticipating significant changes in its industrial structure and in its labor force.

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Techniques of Manpower Assessment

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1. This paper treats the subject of manpower assessment techniques in two parts. The first is a general discussion of basic problems involved in dealing with manpower assessment, the second is concerned with the procedures particularly relevant to manpower assessment in Turkey.

Part I—General

2. Assessment of manpower is an essential requirement for sound economic and social planning. Basic to determining the relationship between labor demand and supply, both quantitatively and qualitatively, as it exists and as it is expected to develop, is the organization, evaluation, and projection of essential manpower data. The listing of the informational sources necessary for these purposes has been set forth in varying detail on numerous occasions. They are precedent to establishing the framework for manpower analysis and program implementation.

3. In essence they consist of factual data or reasonable estimates of the total population broken down into various components. These consist initially of sex and age groupings, degrees of literacy and educational achievement, urban and rural distributions, and rates of population increase. Additionally, as much detail as is feasible should be obtained on the industrial and occupational distribution of the labor force, the variety and characteristics of work force skill improvement programs, patterns of technical change and programmed economic growth. All of these sources of data then need to be organized so as to establish the relationships of labor demand and supply for the periods of projection by economic sector, occupationally, industrially and/or regionally, and to indicate the procedures or machinery by which the various types of demand and supply can be most effectively matched.

4. The wide variations in data resources which exist from country to country among less developed areas make it extremely difficult to follow any standard type of approach. The expert, however, must investigate initially all official

source materials as realistically as possible. Perhaps the most important single reference source would be the latest population census. However, careful consideration must be given as to the collection methods used, whether a full count or sample, the extent of geographical coverage, the items of information collected, occupational and industrial attachments, age, sex, education, etc. Particular emphasis must be placed on the degree of detail and the acceptability of the industrial and occupational classifications used in the census. Additional information on migration patterns, rates of population growth by sectors (rural and urban), and shifts of population from one to the other, the concentrations and characteristics of non-agricultural employment and the particular nature of the rural sector activities are extremely important. They provide the guidelines within which intensive evaluation and projections must be developed.

5. Official censuses or other benchmark data frequently offer special difficulties. These may be due to their lack of recency or their incompleteness, especially in relation to labor force characteristics and industrial attachments. There is also the inconsistency in the use of industrial and occupational classifications which may make for non-comparability with previous census materials or with current economic data from operating industrial or governmental sectors. Additionally, there are the questionable results obtained in national census due to limited sampling of households with regard to labor force participation. Coupled with this is the limited training of enumerators in the use of these specialized classifications and the degree of accuracy of the responses. Furthermore, there is a large question as to the extent of the applicability of Western labor force concepts to local conditions.

6. The sophisticated concepts of labor force participation, which are generally based on easily categorized industrial wage-job relationships, are often literally transplanted to an entirely different social and economic environment. In many of these less developed sectors the entire family frequently functions as a single economic unit. Unemployment, as defined in the Western economies, is far less significant than underemployment. Also household chores and normal work activity are generally interchangeable in a basically peasant or self-subsistence agricultural economy. Almost all adult females and children from 7 or 8 years of age up are consequently engaged in some useful (economic) function. Thus according to the definitions used in the industrialized societies they would be considered as part of the labor force. It is a fundamental question of how far the industrialized concept of the work force needs adaptation to developing societies where static agriculture generally predominates and involves two-thirds to three-quarters of the total population. Lacking an adequate measure of an age cutoff or definition of home maker for acceptance into the labor force, it is possible to end up with extremely large magnitudes of categories of potential workers for which a developing society should presume to find work opportunities.

7. In post-war Turkey, perhaps 75 percent of the population lives in rural areas and is primarily engaged in peasant type agriculture. Labor force participation as reported in all of the latest censuses has been measured from age 15. In the Philippines, on the other hand, with perhaps 65 percent of the work force engaged in agriculture, likewise mostly in

small holdings, the labor force participation determination starts at age 10. The published Turkish labor force data of the 1950, 1955 and the preliminary 1960 censuses using age 15 as a cutoff are open to considerable question because of the very easily observed fact that a significant proportion of youth under age 15 are actually employed, especially in agriculture.[1] Furthermore, the Turkish Labor Law fully recognizes this fact by requiring that employees covered by that law must keep registers of all workers age 12 and over. There is far greater use of child labor in agriculture, especially in tending sheep and cattle. This is partly attributable to the very limited elementary schooling for the vast majority of Turkish children, especially in rural areas.

8. Similarly, in connection with national population estimates, the relatively advanced Philippines with a well-staffed statistical department and reasonably reliable current vital statistics data as a basis for intercensal population estimates fell some 12 percent short of its population projection for the 1960 census made immediately prior to the actual census count. In other less developed countries census results often open up as many questions as they resolve. For example, in Burma the population census was spread over a 2 year period in 1953–54 partly because of internal political disturbances, the disruption or complete absence of communications in very difficult and hardly explored terrain, and limited technical facilities. The resources available for census enumeration processing and tabulation could at best have only provided some approximate data on which to base any reasonable manpower analyses and projections.

9. One of the manpower assessment methods advocated where local data are inadequate has been to refer to relatively comparable industrial or social structures in other less developed areas as a means of substituting for the local deficiencies. There are many practical advantages in applying this procedure. However, the nominal conformity in both countries to international standard industrial, occupational, statistical, and demographic classifications may disguise the limitations of one country's data and make them subject to use in the host country only with caution.

10. Approaches to manpower assessment in less developed areas must obviously be eclectic. Available statistical and reference materials must be examined intensively and their consistency determined by internal analyses and by reference to operating conditions and specific detailed information found in the environment. They will inevitably need to be supplemented by a series of sample studies in key areas of economic application to round out gaps or to support tentative conclusions based on the limited data at hand. Such studies will also serve to up-date earlier source references and in many instances provide clues to future trends or rates of growth. For example, the character of vocational training school courses which might have been in operation for some years and the acceptability in industry of their graduates may have undergone substantial changes in the intervening period since the data were first compiled. For developing workable procedures and helping provide facilities for supplemental studies, the formation of one or more technical advisory committees consisting of economists, statisticians, engineering specialists, educators, government manpower administrators and training experts can be extremely productive. They will tend

to keep the manpower assessment program firmly tied to the prevailing realities of the local environment.

11. Each country's manpower assessment problem has unique aspects and one may find unexpected, acceptable data sources where least expected. A plantation economy such as Ceylon's has continued to function on the basis of three major export crops—tea, rubber and coconut. The first two provide most of the export revenues. These highly commercial operations on substantially predetermined acreages by reason of soil and climatic conditions use commercially tested and internationally competitive processes which have enabled them to operate effectively for several decades. Generally, they are fairly large scale operations run by well established and financially stable enterprises. The measure of manpower requirements per crop-acre including supporting services, plus the limited possible change in their output, processing technology and productivity per worker, make determinations of manpower staffing patterns and requirements relatively reliable and simple to project. Furthermore, because of the special characteristics of the originally imported plantation labor, protective labor legislation insures continuous and complete records of employment by occupation, wages, days worked, resident populations, supplementary educational, health, welfare services and the like. In other developing countries, comparable data might be available for basic industrial activities such as oil extraction and refining, for coal, tin or bauxite mining and smelting, etc.

12. On the other hand, a generally peasant-type, small-holding, predominantly agricultural economy (common among many less developed nations) likewise can provide some reasonable assumptions for manpower requirements in terms of family (economic) units and resident populations. The rural sector by and large lacks the infrastructure for rapid advancement into a technological age—good allweather roads, adequate transport, communications, electric power, diversity of industrial activities, large capital investments per worker and above all, education, literacy, and exposure to modern technology.

13. It is true that governments are making great efforts to speed the economic and cultural transition of their rural societies by pushing road building programs, providing railways and motorized transport, marketing facilities, schools, health and welfare amenities, and other desirable programs. In differing degrees these programs will necessarily open possibilities of geographic and occupational mobility to this largely static, dispersed and unintegrated population sector.

14. Such governments must, however, consider other priorities within their overall national economic development objectives. They must budget their limited developmental resources accordingly. One undoubted result of the development efforts which have affected the hitherto static rural economy is the drawing off of a part of the excess rural populations into the cities as a concomitant of the increased mobility due to the rapidity of post war changes as compared with the preceding decades.

15. Additionally, programs of land reform, agricultural demonstration farms, resettlement and irrigation schemes, as well as the expansion of large scale commercial crop acreages in cotton, tobacco, sugar cane or beet, etc. may have an expanding impact on the traditional agri-

cultural structure. They in turn would develop supporting non-agricultural activities such as sugar mills, cotton gins, canneries, tractor and machinery repair centers, road maintenance, etc. But in relation to the numbers engaged in subsistence farming, the total effect in diversification of economic opportunities is quite limited. For years to come, the changes in the structure of traditional rural society and in economic patterns will be gradual, and characteristics of low income and considerable underutilized labor resources will continue.

16. Underemployment in agriculture may be endemic (and partly a natural consequence of an industrial activity tied to seasonal and weather conditions), and its productivity extremely low in the traditionally operated peasant holding. There is nevertheless, little likelihood of any radical change in that way of life or in its manpower utilization pattern in any period for which manpower projections are feasible.

17. Any stimulus to improved productivity through government aided cooperatives, intensive or diversified agriculture, improved seeds, tools or fertilizers, etc. will be largely offset by the rapid growth of rural populations and increased consumption of the additional output with relatively little rise in the standard of living (c/f India's experience during its past Five Year Plans). It the nation's planned infrastructure and its educational programs develop to a reasonable degree in the rural sector, a predictable consequence will be the intensification of the movement from the large reservoir of underutilized labor supply from isolated rural areas to the growing urban centers. This will often increase the size of the urban unemployed work force, the numbers of marginally employed, and the proliferation of so-called self-employed street vendors, lottery ticket salesmen, second hand goods dealers, etc.

18. The manpower assessment problem thus can be divided into two complementary efforts: (a) A moderately intensive analysis of the agricultural labor force and employment situation, which, because of the slowness of change, need be repeated only at infrequent intervals; and (b) a more intensive assessment and frequent re-assessment of the non-agricultural labor force and employment situation in the light of changing conditions and with reference to new bench-marks.

19. Governments in the less developed countries play an increasingly important part in the determination of the kind, magnitude and location of industrial and related economic developments by their control of the planning machinery, investment policy, credit facilities, foreign exchange allotments, tax incentives, etc. It is thus possible to attack the problem of manpower measurement in terms of (a) specific government programs now under way as to employment patterns, occupational shortages, skill development practices, etc. (b) short term projects about to be undertaken with consideration for their manpower requirements and availabilities and (c) long range government programs which may need to be subsequently reviewed as their preliminary target dates appear to be nearing the feasibility stage. Added to these considerations are (d) the historically recent experience of the private sector in its use of manpower resources and its position, predetermined by government or otherwise, to function within the framework of the planned production and service patterns which are the objectives of national policy.

20. Current and projected manpower data which can be gathered most easily are those from government owned or semi-public enterprises. These, however, need to be qualified by realistic judgments of the likelihood of the accomplishment of government production targets. Many of these projects may have, for internal political or other reasons, been programmed beyond their economic feasibility. Perhaps due account has not been accorded to long range financing sources for major physical facilities or proper determinations made of costs and/or market absorptive capacities.

21. Perhaps one of the most fruitful sources on which the manpower assessment can depend are the several specialized reports on aspects of the economy by AID, international agencies experts or private consultants. These may deal with financial, commercial, industrial, agricultural, educational, health, power, communications, transportation or other areas of special concern. They will provide reasonably sound guidelines in their strictly limited areas of interest for manpower assessment, current and projected. They are effective tools for translating economic development objectives into prospective manpower target ranges.

22. In each case, program magnitudes and probability goals are usually set forth and frequently contain estimates of specialized key manpower needs. Where a government might aspire to universal elementary education and seek to achieve pupil-teacher ratios in elementary or secondary schools not too far out of line with those in more developed countries, it is possible to estimate the number of additional school rooms to be constructed, the additional teachers required and the related teacher training facilities. Where a radical increase in doctors per 10,000 population is set as a government target in "X" years, the medical survey expert's evaluation of the facilities needed for expanded doctor training, for the development of an acceptable professional level of proficiency, for the increase in the number of hospitals and supporting technicians and the attrition rates for medical personnel now in practice, will furnish sound bases for sectoral manpower analysis in that specialized area.

23. Another indispensable approach to manpower assessment, particularly in establishing a foundation for current distributions of the non-agricultural work force are the periodic or intermittent (annual) reports of government such as statistical series of the central statistical office, surveys of manufactures and commerce, reports of mining output by product, central bank statistics of levels of exports and imports by commodity group and of retail and wholesale trade, reports of immigration and emigration, of employment service activities and social insurance covered employment and payrolls, (and occasionally unemployment) etc. There are also in the private sector, the periodic surveys of their members by chambers of industry and commerce and trade associations. These may occasionally serve as a basis for comparative determinations of manpower input per unit of product or output in industrial sectors.

24. Necessary cautions must be exercised in reviewing such fragmentary or summary employment data as the basis for global estimates and projections because of the frequent underutilization of currently employed personnel in many enterprises, excess overhead manpower (sometimes found in government owned or controlled enterprises) and large amounts of underutilized capacity. When

projections of increased physical output to meet national development targets are utilized as a basis for future manpower requirements, it will frequently be found that the ratio of manpower requirements to increased levels of output may fall as low as 1 to 4 or even 1 to 8 instead of the much more frequently quoted 1 to 2 or 1 to 3 relationship.

25. The most consistent sources of current partial manpower information which may be available are periodic labor market and activity reports of an employment service, a central bank or a central statistical agency. These data may be collected with sufficient frequency from significant non-agricultural establishments to furnish reasonably broad indications of industrial employment trends, staffing patterns, hours worked, and earnings.

26. Where such data are lacking selective establishment surveys by industry, area and size of firm can be executed in a relatively short period of time. These might cover past employment trends, breakdowns of current employment occupationally, by age, sex, and type of worker, labor turnover and attrition rates, and information on sources of recruitment, occupations in short supply, methods of skill acquisition—on the job, apprenticeship, outside vocational training, etc.—as well as forward manpower projections up to 3 to 5 years based on the best judgments of the management in the light of their own economic plans and prospects. Extrapolations for non-covered firms will generally be as effective for global industry manpower estimates and projections as most of the available reference data with which the manpower expert is concerned. As indicated earlier, for certain industrial categories for which occupational detail may be needed, there would be some comparative value in obtaining staffing patterns from outside country sources, if available, of generally comparable stages of economic development.

27. Where the government has established specific priorities of industrial undertakings, the basis for forward estimates are that much enhanced. Staffing patterns for such technically advanced units as modern, large scale plants (steel mills, refineries, smelters, textile mills, cement factories, etc.) can be estimated by reference to their manpower structures in advanced countries. Correspondingly these will need to be adjusted locally for lower employee productivity and for general overstaffing because of ever-present cheap labor supplies in all categories except for the highly skilled, the managerial, technical and professional personnel.

28. Thus all in all, wide perspectives and selectivity of judgment are essential qualifications in assessing manpower requirements. Industrial additions totalling "X" number of new jobs despite allowances for less efficient staffing and lower worker productivity will, nevertheless, create secondary sources of job opportunities ranging perhaps from 1 to 2½ for each new industrial job, depending on the location of the new enterprises in relation to existing urban industrial concentrations. These secondary job opportunities arise out of such activities as housing construction, road building and maintenance, transport services, water and electricity services, expanded wholesale and retail trade, schools, health and welfare facilities, professional personal, domestic, recreation and protection services and above all, expanded government services. In all fields governments strive to become more responsive to the country's growing population needs and its

rising expectations. In developing countries, central and local government employment expands perhaps most rapidly of all industry sectors in a period of continuing economic and social development.

29. On the projected supply side, the rate of educational (and potential skill) development through enlarged elementary, secondary and vocational trade school systems and particularly, the expansion of technical, professional and higher educational institutions are largely dependent on financial considerations and the availability of qualified manpower staffs. How much of the Gross National Product can be devoted to educational sector development in the face of urgent competing claims from agriculture, industry, social welfare, national defense and essential physical infrastructure development is a continuing debate for which there is no set answer.

30. The evaluation of the character and capacity of the educational process to produce the kinds and numbers of workers called for by the evolving character of the industrial structure presents major difficulties. Aside from the question of the rate of achievement of school expansion, the increase in teacher training and required educational plant and facilities, there is the relationship of curriculum geared to the character of the contemplated changes in the economic structure of the society.

31. Perhaps too much emphasis has been placed on the universal appeal in all emerging societies for a free elementary education for everyone, up to, say the eighth grade. This would be an enormous undertaking in itself and would require tremendous financial outlays. It would also utilize a major proportion of the country's educated minority for use in the educational system. Such a program might take decades to achieve. It would undoubtedly hamper the rate of growth in the other, more strategic areas of educational development which are geared directly to the needs of an advancing economic system. It might therefore, be more profitable for balanced economic progress to speed up the development of secondary and technical education even if, heretically speaking, this slows down the wider spread of lower elementary education.

32. Modern society requires higher levels of educational achievement than basic literacy which is what most developing societies universal elementary educational objectives hope to accomplish. The more advanced the technology, the more essential the proportion of secondary, higher technical, and professionally educated requirements become in relation to the total educational process. This is true not only in specialized industrial and scientific fields but as importantly among policy makers, in management, supervision, planning, and staff services.

33. Attempts to evaluate the quantity and quality of output of the educational system in relation to the projected demands (with allowances for attrition, drop outs, etc.) thus become a matter of extreme importance. Manpower assessment must realistically seek the best judgments of the policy makers and the educators to arrive at reasonable determinations of the practical prospects of what the educational objectives will actually achieve in the periods of projection. The statistics of recent output by educational category as a partial guide to the future projections need to be qualified by the test of practical occupational utilization of graduates in the fields of work which utilize their educational foundation. This type of supplementary study

will offer potential judgments on the reality of programmed educational targets for the period of the manpower assessment projections.

34. Whatever estimates are developed must include a wide range of judgment—perhaps a scale of choices of high, low and medium—adjusted for the general shortfalls in production of the professional, technical, managerial and supervisory skills with which less developed countries have been wrestling during recent decades.

35. To develop the needed high level manpower resources on which the momentum of development rests can also serve as a major contribution to the resolution of mass manpower development and utilization at lower skill levels. Specifically designed programs to expedite the development of these high level professional and managerial personnel such as seminars for operating management, graduate training in professional fields, overseas study grants through agencies such as AID, UN, Colombo plan, private foundations, etc. are being implemented on an increasing scale. The staffing patterns for executive and top administrative positions in government, higher educational institutions, as well as private industry, the registers of professional engineering, medical, etc. societies and the number of business proprietors give some indications of the curernt levels of such key personnel in the system. A more than proportionate increase in the ratios in these occupational categories to overall levels of employment in the period of projection will necessarily need to be incorporated into the estimates. How realistic such projection estimates can be must depend on the degree to which the bottleneck in the development of high level personnel is likely to be broken by programs currently underway and in prospect of development.

36. The volume of secondary supporting levels of technicians, foremen and skilled workers can be calculated partly on the bases of the educational, technical and vocational school systems output, and partly on the current practices of the various industrial sectors in developing their own skill resources. (In some areas the ratios or ranges of supporting skills can be obtained by comparative reference to developments elsewhere, for example, the number of medical technicians, nurses, etc. per 1000 hospital beds, the number of surveyors and field crews per 100 kilometers of road construction, etc.) Sample studies of establishments, staffing patterns, recruitment policies, on-the-job training, and promotion policies as suggested earlier, will also provide clues to the extent to which the industrial sectors are able to develop the numbers and types of supporting skills needed to maintain the balanced employment structures needed for improved productivity and economic progress.

37. The measurement of the availabilities and requirements by industrial sector and/or occupational group for the periods considered in the manpower assessment will serve to indicate the degrees of balance or shortage which might broadly be anticipated. The nature of the actions designed to resolve the discrepancies should follow in the form of manpower plans and programs, both short and longer range. These should be organized and carried out by the government agencies concerned with those specific areas of activity, preferably under the coordination and general guidance of a central planning agency with procedures for continuing program review,

evaluation and possible modification in accordance with the dynamics of the changing economic environment.

Part II—Manpower Assessment in Turkey

38. Turkey illustrates the general position taken in the previous section of the article: methodology in manpower assessment follows the purposes of such assessment, characteristics of the country and availability of data. There are also some special factors including the background and interests of the people doing the assessment.

39. In Turkey, the assessment has been done almost entirely in the State Planning Organization, and consists of long-range projections of labor force, manpower requirements and educational targets. Currently, at the stage of filling in gaps by more intensive analysis, other agencies such as the Employment Service and the Bureau of Educational Research and Evaluation of the Ministry of Education are being enlisted in the effort. The assessment has been strongly influenced by Turkey's participation in the Mediterranean Regional Project, "Targets and Programmes For Education and Priorities For Specialized Manpower in Relation to Economic Development", sponsored by OECD. Advisors of ILO and AID have had some influence on the assessment. The manpower study by Italy's SVIMEZ[2] served as a model for the early analysis, but basically the analysis bears the stamp of the staff in the Social Planning Department of the State Planning Organization, and the relation of manpower planning to the general character of Turkey's Long Range Development Plan.

40. *Manpower and Educational Policy in the Plan.* Turkey has a Five-Year Plan in a 15-year perspective. In addition to general objectives of improved living standards and social conditions for the people, there are specific policy statements covering the development of adequate trained manpower for the needs of the plan, and the employment of unused manpower. In relation to the first objective, the main purpose of manpower assessment is to show future requirements for trained manpower and the educational and training capacity needed to meet these requirements. With respect to the second objective, the purpose of the assessment is to show the relation between growth of labor force and probable employment, as a guide to measures for counteracting unemployment and underemployment.

41. In these respects Turkey does not differ fundamentally from a number of other developing countries, but the points of emphasis and the nature of the analysis have some unique characteristics. For one thing, Turkey has, perhaps more than most developing countries, the contrast between "modern" and "traditional" societies. Turkey, as a member of NATO and OECD, and a prospective associate member of the European Common Market, is committed to participation in both modern technological development and the secular culture of the West. At the same time, the peasants of the Anatolian Plateau village, the wandering seasonal workers of the eastern Black Sea region or the Adana Plain (S.E. Mediterranean) area (and even many residents of towns and cities) are part of an ancient traditional society.

42. This situation, along with the problems related to rapid population growth,

have sharpened Turkey's dilemma with regard to employment policy. On the one hand, there must be a quick and substantial increase in labor productivity in export and "import substitution" industries in order to improve the balance of payments situation and prepare the way for association with the Common Market; on the other hand, there is a need to utilize idle manpower and to emphasize labor-intensive production to the maximum extent feasible.

43. This dilemma is reflected in the approach to manpower assessment. The analysis of industrial and service sector manpower is based on the need to increase the supply of trained manpower at a rapid rate; the analysis of agricultural and rural manpower is based primarily on seeking means of utilizing surplus manpower.

44. *Availability of Data.* Turkey is in a middle position for developing countries with regard to manpower data. Population census data, while of questionable accuracy in some cases and late in tabulation, is rather sophisticated with regard to labor force and employment data. Among the weaknesses of the census material are the over-estimate of the economically active population in the rural areas, an apparent underestimate of unemployment, and the lack of detailed cross-tabulation of occupations by economic activity. The census occurs in five-year intervals, and there are no reliable labor force or employment data in the interim. Full tabulation of the 1955 census was not available until early 1962, and the date of availability for the 1960 census is indefinite. In addition to the census, there are partial data on employment in non-agricultural activities from such sources as workers' insurance records, industrial surveys and Employment Service activity reports. For agriculture, which accounts for 75 percent of the labor force, manpower data are scarce indeed.

45. *Methodology in Turkey's Manpower Projections.* The long-range projections for manpower and education have been based on a survey and analysis of existing data by the State Planning Organization, and methods are described in a document entitled "Methodological Outline of the Manpower and Education Aspects of the Plan, May 1962". From this report the following paragraph is quoted to indicate purposes of the analysis:

"The purpose of this survey is to: (a) project the total employment that will be created by the expected development during plan periods as the basis of employment policies; (b) forecast the demand for various categories of skills; (c) set-up targets for the mechanisms of supply (educational institutions, training within industry, etc.) in order to avoid shortages of skills which may be an important bottleneck in the implementation of the plan; (d) prepare a framework for an integrated plan for education and training considering the interrelation between various types of schools in terms of quantitative adjustments, time lags teacher supply and cost estimates."

46. The first step was to take "inventories" of the labor force and its distribution for the years 1955, 1960 and 1962. For 1955 the population census was the source of data, and a cross-tabulation in medium detail of labor force by occupational groups and economic activity was available. Occupations were grouped into seven functional categories.[3]

47. The 1960 and 1962 inventories were based primarily on data from a one percent sample tabulation of the 1960 census, with projections for 1962. De-

tails were supplied by projection from 1955 census. These were checked and corrected by reference to industrial census data for 1958–1959, a register of establishments of the Ministry of Industries, and a special survey by the State Planning Organization in the State Economic Enterprises.

48. Manpower demand for future years for industry and services is based on the concept of "Elasticity of Labor Demand in Respect to Production". For manufacturing the ratio of employment to production, and for construction, the ratio of employment to investment was used.[4]

49. Agricultural employment estimates were made on a different basis, related to population growth. It is assumed that the agricultural labor force will increase slowly and for the most part, expanded output will only absorb present disguised unemployment. Excess beyond this would migrate to the towns and cities. Requirements for certain types of professional and technical personnel to be employed in agricultural programs (e.g. research and extension) were included in the industry-services category.

50. *Education Requirements.* To begin with, manpower requirements were related to educational levels and types according to the following table:

TABLE 1. *The interrelationship between functional categories and educational categories* [5]

Educational categories	*Functional categories*
General higher education Technical higher education Technical teacher training schools Teacher training schools	Administrators and entrepreneurs Professional personnel
Teacher training schools (primary) Technical schools at the lycee levels Professional lycees	Technicians
Lycees Secondary schools	Supply for higher schools
On-the-job training	Foremen and skilled labor

51. The number of graduates of each level and type school was estimated for future years. Additional capacity to be added to meet manpower needs was estimated for each type and level of school. In addition to the direct requirements for these types of trained personnel, the capacity of elementary schools to meet the goal of universal primary education was added. Details were adjusted for attrition and for increased teacher demand to improve the present teacher-student ratios. Finally, costs were estimated, both for investment and current expenditures, to provide the new educational capacity.

52. It is assumed that skilled workers and 90 percent of foremen in industry will be trained on the job.

53. *Estimates of Labor Force, Unemployment and Underemployment.* Estimates of "disguised unemployment" in agriculture were made by calculating the number of man-days required each month

for various crops and animal husbandry, and comparing these with the total number of workers in the agricultural labor force. This showed a large seasonal variation in labor requirements, and even at peak season a surplus of labor supply.

54. Estimates of current unemployment in non-agricultural sectors have been difficult to make. The population census figure of a few thousand unemployed is considered unrealistically low. Reports of applicants at the employment service for whom jobs cannot be found cover only a small fraction of the labor market. For this reason estimates of unemployment have been based on efforts to gauge the gap between estimated labor force and estimated employment. Labor force estimates stem from population analysis and projections by age and sex. Certain assumptions were made about labor force participation rates of males and females of working age. Employment forecasts are from the same sources as described in preceding sections. The gap between labor force and employment is considered to be "potential unemployment".

55. *Detailed Studies.* Following the completion of these global forecasts, the State Planning Organization has sponsored detailed studies of manpower supply and demand for selected priority industrial sectors (e.g. basic chemicals, iron and steel) and for scientific, technical, and managerial personnel in all sectors. The supply-demand surveys are preceded by development of standard occupational titles and descriptions corresponding to the International Standard Classification of Occupations.

56. *Evaluation.* The problem of Turkey's manpower assessment is that the methods are more refined than the data which are frequently limited in coverage, detail, and recency. The results, therefore, give an appearance of precision which could be misleading. This is, perhaps, inevitable when producing quantitative forecasts to fit the framework of a development plan. In any case, the emphasis given to the manpower factor in Turkey's Plan is commendable.

57. The methodology is generally consistent with recent practice and guidelines of ILO, OECD, and American specialists. In the application, there are some doubtful assumptions, largely because of the lack of data or the uncertain accuracy of the data which are available. In projecting the size of the labor force, the main problem is that past censuses have overcounted the number of females in agriculture who are economically active. Also starting the age of the labor force at 15 is unrealistic for Turkey. It should be as low as 12 or even 10. In the employment projections, reliance has been placed on elasticities of employment in relation to production (investment in the case of construction), based on European nations' experience and with limited reference to post war trends in Turkey. The trouble is that the figures for past trends are not very reliable; further, that the historical situation in most of Europe is not necessarily applicable to near future conditions in Turkey. The result may be an unrealistic forecast of the employment level.

58. In the estimate of unemployment, both the data and the assumptions are subject to reservations. This has been pointed out in the first part of this paper with reference to the measurement of the effective labor force, the overestimate of female participation rates and some partial treatment of agricultural under employment in the framework of regular employment. An additional assumption

that requires considerable validation is the matching of educational system graduate output with the quantitative requirements for technical, skilled and related occupations in attempting to equate supply and demand magnitudes in those broad occupational categories.

59. On the whole, Turkey's technicians have done well with the data at hand, and are themselves aware of the weaknesses. They also are making efforts to obtain improved data in the future and are continuing to re-examine the assumptions and conclusions.

FOOTNOTES

[1] The latest censuses furnish limited information on work activities of those age 6–14 but do not count them in the official work force totals.

[2] *Trained Manpower Requirements for the Economic Development of Italy,* Association for the Industrial Development of Southern Italy, Rome, (1961).

[3] Managers and administrative personnel
Professional personnel
Technicians
Clerical and sales personnel
Foremen
Skilled labor
Unskilled labor

[4] "Elasticity" coefficients ranged for 0.4 to 0.9 for various industry sectors. Estimated productivity increase in industry is 2.2 percent annual for the years 1963–67; 2.8 percent for 1968–72; and 3.3 percent for 1973–77.

[5] *Turkey's Manpower Requirements and Education Targets, 1962–1977.* State Planning Organization, Ankara, (May 1962.)

The Entrepreneurial Element in Economic Development*

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1. Much has been written on entrepreneurship in the literature concerning economic growth, and this variable customarily is designated as a pertinent factor in economic development. Although there have been case studies of the emergence of entrepreneurship in several developing countries, generalizations on entrepreneurial roles and contributions have been rare; there is even some uncertainty as to the proper definition of the concept. This paper suggests some general principles relating to the performance of entrepreneurial functions in the process of economic growth, in general, and in the developing countries, in particular.

2. The definition of entrepreneurship, as of many other concepts in economics, does not lend itself to uniformity. Entrepreneurs are classed by some primarily as innovators; others regard them as managers of enterprises, and bearers of risks; some place major emphasis on their functions as mobilizers and allocators of capital. Joseph Schumpeter, in 1912, expressed the view that the specific role of entrepreneurs is in the carrying out of innovations. Schumpeter wrote at a time when most entrepreneurial performance was in the hands of private individuals, and government and private bureaucracies still played a relatively limited part in the running of economically significant enterprises. In the past 50 years, however, the corporation and other highly structured public units perform more and more of the main entrepreneurial function in countries whose economy is traditionally based on free enterprise. In socialist countries public officials working in government enterprises or government-controlled corporations may carry the entrepreneurial function; in the developing countries government officials may control some important branches of production. Hence, the individual, "irrational", visionary enterpreneur whom Schumpeter saw as the main carrier of economic progress has been largely replaced by a private or public "business leader" whose action may be based on known and predictable principles, whose risk has been greatly reduced, and whose activities are supported by a large corporation or a governmental agency. These functions have become so routine that the performance of the typical entre-

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*UN conference paper.

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preneurial functions stipulated by Schumpeter has become either impossible or superfluous.

3. The concept of entrepreneurship as advanced by Schumpeter has been modified in light of the developments in the last few decades, especially in Asian and African countries. Most of the business leadership in these countries is, or may be, carried out by managers of large private or public enterprises, or by small or medium-scale entrepreneurs. Scarcely any of these are innovators in the Schumpeter sense. The technology applied is usually borrowed from abroad. The legal and marketing practices are generally adaptations from more economically advanced countries. Often the commodities produced are imitations of the consumer goods of the more advanced nations.

4. In view of these considerations, it is necessary to modify Schumpeter's description of entrepreneurship and entrepreneurial functions. The person who typically performs this function in developing countries today may be either a manager or one who adapts the experience of others in production methods, sources of supply, and markets to conditions prevailing in newly developing countries. In the subsequent discussion, we will be concerned primarily with individuals who are active as business leaders in the private sector. The facts of economic development in Asia and Africa seem to indicate that an important role in this process may be played by private entrepreneurs in small and medium-scale plants, provided a private enterprise sector is at all in existence. In addition, there must be within the framework of government plans for economic development some intention to develop "mixed economies" in which business and private enterprise combine for the improvement of the economic welfare.

5. In short, we are concerned with private entrepreneurs who are active in the small and medium-size industrial, commercial, and financial enterprises which are appearing or will appear in the economically less developed nations. Many of the entrepreneurial characteristics will also apply to persons in positions of business leadership in the public sector. In some cases the differences that result from the different responses of the private and public business leaders will be pointed up.

6. It may be useful to cite a few figures indicating the general significance of small and medium-scale private entrepreneurs in the process of industrialization and general economic growth in developing countries. If we classify industrial establishments in terms of the number of workers employed and assign enterprises employing fewer than 50 persons to the class of small and medium-scale plants, we find the following data from the economic experiences of some Western European countries: in Austria, in 1930, 57.7 percent of the total labor force in secondary production (manufacturing, mining, and construction) worked in firms employing fewer than 50 workers. The corresponding figures for other countries were as follows: in France, in 1906, the percentage was 70.6; in Germany, in 1907, it was 54.5; in Switzerland, in 1955, it was 43.7; and in Norway, in 1953, it was 51.3. From these figures it becomes apparent that small and medium-sized plants have played an important part in industrial countries, and that even long after the onset of the industrialization process the majority of workers in secondary produc-

tion were employed in these "small" firms. The corresponding proportions for commercial activities, especially retail trade, and for financial activities, except investment banking and modern types of insurance, are probably much higher than those in secondary industries. In brief, the small and medium-scale firm can be said to have played an important part in the more highly developed countries and may be expected to play an important part in the process of economic growth in the development countries.

7. But there are still other reasons emphasizing these enterprises in developing countries, especially those with dense populations and large labor supply. It is quite customary, when we think of industrial development in the new nations, to evoke the picture of a large scale industrial plant; e.g., in steel or cement production. But the existing markets, demand patterns, and conditions of comparative advantage in developing countries are such as to make the establishment of small plants, mainly producing light consumers' goods, most attractive. Hence, industrialization must be thought of in the next two or three decades not in terms of new Pittsburghs or Birminghams in the developing nations of Asia and Africa, but rather as a process in which small capital is allocated in various industrial and commercial fields. Although these units may increase in size, they will remain—from a world point of view—fairly small, or at best medium-sized, in their fields of economic activity. The reason for this stems from the very different relative supply of labor and capital, and particularly from the fact that capital to be invested on a long-term basis is in very short supply and often unavailable through the ordinary channels. In other words, banks will ration credit to small entrepreneurs who wish to grow rapidly. Many enterprises may have to begin with meager capital funds and grow only to the extent to which they can reinvest their profits. In the industrial field the certainty that small and medium-scale enterprises in the developing countries will persist must be taken into account. In the light of Western Europe's historical experience entrepreneurs on the small and medium scale will have important roles for several decades.

8. Up to this point no distinction has been drawn between the different areas of economic activity in which entrepreneurship is exercised. Moreover, in the literature of entrepreneurship little or no distinction has been made usually among the fields of entrepreneurship. Yet, a superficial study of business leaders in many developing countries shows that industrial entrepreneurship falls far short of the degree to which commercial and financial entrepreneurship flourishes. Why do we find in so many developing countries no dearth of moneylenders and traders but so few indigenous industrialists? For example, in almost all the new Nations of West Africa, there are extended networks of trade in which Africans, persons of Middle Eastern origin, and other Mediterranean people participate. Yet few of these persons engage in industrial pursuits. A similar situation is noticeable in several East African countries and in various parts of Southeastern Asia. Various arguments have been raised to explain this phenomenon. Foremost is the fact that local industrialists, especially in former colonial areas, were unable to compete with the powerful enterprises set up by Europeans. A similar argument may be made for those developing countries which were politi-

cally independent but whose potential entrepreneurs faced the overwhelming competition of foreign investors. Most European foreign investments were concentrated in such basic industries as mining, transport, and power, and only small proportions of private foreign capital flowed into manufacturing. A look at the kind of enterprises which entrepreneurs established in trading and moneylending fields shows that they were often supplementary to the similar activities of European firms. The small indigenous traders and moneylenders had to find their places in the unoccupied interstices of the economic system. They mediated between the urban centers and the countryside; they provisioned small retailers; they serviced the financial needs of rural and semi-rural populations unable to offer bankable securities; and they distributed commodities on a scale that would have been uneconomical for the large foreign enterprises.

9. Why do we not witness similar developments in the industrial field? Clearly we should not expect that the small indigenous entrepreneurs would have competed with the large foreign mining or transport companies. There were and are, however, numerous industrial branches in which ample opportunities exist for the establishment of small and medium scale plants providing for the role of trader and moneylender with regard to the foreign import houses, wholesalers and bankers. This difference in behavior in different economic fields by indigenous entrepreneurs stems from the fact that economic development everywhere is tied, to a substantial degree, to the growth of industry. In mixed economies industrial growth is confined to a few large establishments, mainly in the field of heavy industry. However, highly significant is the rapid growth of many small and medium-scale firms producing consumer goods and offering services. Hence, the gaining of a clearer insight into the different conditions under which industrial, as against commercial and financial, entrepreneurship may flourish in a developing country may be an important guide for over-all economic policies.

10. A reason advanced for the sluggishness of industrial entrepreneurship in developing countries turns on the talents required to guide an industrial enterprise. These talents differ from those needed for most successful commercial or financial dealings. A small trader or moneylender can operate successfully with only a few, and often without any, permanently employed assistants, but the industrial entrepreneur—provided he is more than a craftsman or artisan—usually must hire men or women whose work he must organize and guide. In short, we may presume that an industrial entrepreneur must have a broader range of abilities than a moneylender or trader. He must be a person who can lead others in a common enterprise and he must have technical knowledge in his branch of production.

11. Another distinction between industrial entrepreneurs and financial or commercial entrepreneurs is found in the commitment of assets in the production process. A trader may carry on his operation without ever attaining property rights to the object he deals with; if he is a broker or commercial agent, he may merely lose his earnings from a transaction but not the capital invested in it. In addition, the capital that a trader, or moneylender, does invest has a faster turnover normally than that invested in an industrial establishment. Moreover, a moneylender or banker deals in a com-

modity that has the widest currency, that is accepted by everyone, and that can be easily transported, hidden, or converted into other assets. On the other hand, an industrial entrepreneur usually has a much larger proportion of his assets tied up in fixed capital. He often depends on an imperfect market for the sale of his output; his profit is exposed to dangers which moneylenders or traders sometimes escape. Other things being equal, the risk of transforming a given amount of capital into industrial assets is much greater than in trading or financial operations. A commitment of one's property to investment in industry normally implies a longer-term commitment, and this increases the uncertainty. There is less flexibility in an operation once capital has taken the form of fixed assets, and the prospective profitability of an enterprise is more directly influenced by changes in taste and fluctuations in demand than is true for capital invested in commerce or finance.

12. Thus, entrepreneurship depends partly upon the appearance of persons with a psychological make-up for entrepreneurial activity, and partly on the social and economic environment that would make it an attractive venture to such individuals. Since many developing nations wish to create a climate favorable for the rapid development of entrepreneurship, especially industrial entrepreneurship, a detailed discussion of the ways in which these personal and environmental conditions can be enhanced may be helpful. The significance of the psychological dispositions for entrepreneurial activity is quite clear from the preceding discussion. Some writers have made these personality factors the fully determining conditions of economic innovations and economic growth, but this appears perhaps too extreme a position. There is little doubt that features in the environment can be manipulated with much more predictable outcomes than can the shaping of personality development. In brief, we may consider that certain conditions in the economy will make possible the successful exercise of entrepreneurial functions regardless of the relative abundance or scarcity of certain personality types.

13. These conditions of the economy may be classified as consisting, on the one hand, of certain forms of social and economic overhead capital, and, on the other, of certain governmental services which are placed at the disposal of entrepreneurs. One such condition is the maintenance of law and order. Involved here are the distribution of status and political power, the manner in which power affects entrepreneurial functions and the business community's part in the making of political decisions. A system of private enterprise can exist only if the following basic conditions in the legal-political field are met:

(a) Governmental action short of complete non-intervention but so designed that it does not deny to private persons, explicitly or implicitly, any kind of autonomy in decision-making in the economic field.

(b) A minimum provision of legal, and legally enforceable, institutional rules according to which private economic decisions can be made and implemented.

(c) Protection of the assets owned by an enterprise against expropriation by others, and protection of the contractual relationships entered into by business leaders with one another or with outsiders.

14. These conditions in some historical situations have been forced upon governments by the political action of business leaders and their political allies. The Industrial Revolution, whether it arose gradually through a process of legal and political reform, as in Britain, or was strongly supported by a political revolution, as in France in 1789, generally altered the prevailing legal and political system—a lessening of arbitrary privileges in the economic area for the aristocracy, no more special treatment of certain privileged groups, wider access to the elite from the ranks of the business community, and a forum (Parliament or some less visible arena) in which pressures by business leaders for legislation in support of their most important needs could be exercised. In other countries the processes by which this greater participation and protection of the entrepreneurial community were achieved differed. In Germany a political alliance was concluded between the aristocratic junkers and the interests of industrial enterprise. In many of the ex-colonial countries the development of entrepreneurship—the pattern which Max Weber called "pariah entrepreneurship" was based largely on a European system of legal security and predictability imposed upon these countries. In Japan, finally, this system was attained with a minimum modification of the social structure, primarily because the elite were persuaded to realization of the nation's needs and to the wisdom of adopting Western technology and economic organization.

15. The crucial lesson of these instances teaches that private entrepreneurship will develop only if the legal order provides the necessary accommodation for the needs and protection of entrepreneurial activity. Accommodation must include not merely the promulgation of a "neutral" system of laws, but also the shaping of institutions through which entrepreneurs can exert pressure on actions of the state and especially upon legislation. In the change, entrepreneurial performance may rise to a level where it can provide not wealth alone but also social status and some form of political influence. But if those favorable conditions are not created, other outcomes are possible. One is socialization of all enterprise, the government assuming all decisions in the economic realm, the establishment, in short, of a fully planned economy after abolition of private enterprise. A second possibility is the establishment of a system of statism, such as existed in Turkey in the inter-War period, in which private enterprise nominally exists but actually functions under the full direction of the Government. A third is the neglect of enterprise altogether and subsequent stagnation of the economy. Thus, the creation of a "climate of entrepreneurship" has not only economic and social dimensions, but also a political one.

16. In the establishment of a social structure conducive to the development of entrepreneurship, the feature of economic overhead capital must not be overlooked, since provision of this capital influences the development of entrepreneurship in a positive direction. Most important is provision of power for industry and of transport facilities. These two are perhaps the most significant items in the vast variety of economic overhead capital whose presence in abundance encourages the growth of industrial and commercial enterprise. It is not necessary to enlarge on the importance of power; without it modern productive processes are impossible. Nor is it necessary to expand on transport facilities, since their lack has severely

limited markets and prevented establishment of some industries. But it is paramount to state that the less developed a region is, the greater the need for a good transport network.

17. In this discussion of socio-economic environment we have moved from the most difficult features to the less difficult. The most significant and most difficult is the creation of an appropriate psychological and political structure for entrepreneurial effort. Slightly less important and easier to provide, given the necessary financial resources, are facilities for power and transport. Easier still is the establishment of various government agencies to offer, either without charge or at low cost, services of importance to an entrepreneurial community. Among these services are information on markets, sources of supply, technical innovation, internal organization of plants, innovations in design, and other technical matters which the small and medium-scale entrepreneur in a devolping country finds difficult to obtain on his own. Markets in most developing countries are too small and too confined to make the publication of technical and marketing journals attractive. Thus, business leaders must and often do rely upon government for this information.

18. In addition to the technical information of use to entrepreneurs, the government may offer other services at low cost or as a subsidy. These services may include assistance with accounting, long-term credit, and the provision of various types of technical education. The need for such services has been widely recognized and, in several developing countries, appropriate institutions have been created to supply them. The agencies charged with providing the services bear different names, but have been designated collectively as development banks or development corporations. Common to all these development corporations is the function of providing credit to entrepreneurs, particularly for long-term needs. In addition to the credit-financing function, the development corporations should provide technical and economic information useful to new enterprises in the earliest stages of their activity.

19. The development bank should have facilities to find out where the most suitable machinery can be purchased; to supply information on industrialists' markets, freight charges, insurance costs, and other expenses incurred in establishing new business. It will have better information than most traders. Its staff, after examination of production processes, can develop a system of accounting which will be relatively simple and accurate and will meet the needs of the entrepreneur at each stage of his operation. It may even establish a department to acquire machinery to sell to new firms on a hire-purchase plan. Finally, it may cooperate with new firms to find suitable locations and design work procedures and related patterns of practical operations which make for sound production and at the same time reduce the cost of productive operations.

20. In many developing countries in which industrial development banks have been established, financing activities are largely confined to larger-scale enterprises. This is understandable. The technical assistance these firms need is proportionately less than that needed by smaller firms. In most larger establishments the chief assistance needed by entrepreneurs is long-term credit. In smaller firms the chief requirement is advisory services of various kinds, in addition to credit. Also, the manpower training required, al-

though it may be more extensive than training of managers of large private or public corporations, is oriented toward the economic, organizational and technological processes on which their enterprises are likely to concentrate. This suggests that the development of commercial, financial, and especially industrial entrepreneurship on a wider basis requires not only different approaches by banks and government information services but also by educational services.

21. Successful entrepreneurship, this paper has argued, implies the exercise of leadership, maturity of character, a sense of security and knowledge of, or familiarity with, the skills related to the entrepreneur's undertakings. The entrepreneur is a man with the broad view, as distinguished from the technical or economic specialist, but familiarity with technical aspects of production is helpful where it is not imperative. Here he differs from the expert of a large enterprise who is employed for his specialized or technical knowledge of production, purchasing, labor relations or other limited and well-defined spheres of action. The entrepreneur in a small or medium-size plant must be more than a man with some knowledge of the production techniques employed in the plant; he must be also a person who makes the chief decision relating to sales, supplies, production processes, relations with workers and numerous elements of business. Primarily he must display characteristics of personality and leadership, the willingness to take some risks and the desire to perform his role successfully.

22. Because of the basic personality characteristics essential to leadership, the training of the entrepreneur is of major significance. This is especially true in industry—as has already been pointed out—where the entrepreneur must be informed on matters relating to the technical processes. Education and on-the-job training in a growing establishment are prime sources for the acquisition of this information. For example, an entrepreneur who wishes to start a foundry should be able to obtain access to an enterprise at home, if foundries are already in operation there. Otherwise, he should visit nearby developing countries which have foundries.

23. Up to this point we have been concerned with the analysis of external factors which may influence the growth and encouragement of entrepreneurship in developing countries. In the last resort, the appearance of entrepreneurs is a matter of changing human effort and human action. However, we must also consider certain aspects of recruiting and promoting a corps of entrepreneurs in developing countries. In dealing with this problem we are in one of the most disputed and uncertain areas of social research relating to developing countries. Opinions concerning the human factor in entrepreneurship range all the way from sheer resignation from the impossible task of dealing with this factor meaningfully, to the other extreme of prescribing elaborate schooling and training programs.

24. The psychological aspects of entrepreneurship have been treated principally by E. E. Hagen and D. C. McClelland, each stressing somewhat different characteristics. In brief, the generally accepted viewpoint on the psychological dimension in entrepreneurial action may be summarized as follows: The industrial entrepreneur, and in fact, the innovating entrepreneur in general, is a distinct personality type. He must be persuaded that

change can occur and that it can be brought about by individual action. He also must be motivated to bring about this change by his own activity. This is why—as we have maintained earlier—the general standards of a society must allow persons with newly acquired wealth some access to power or prestige. If overwhelming social obstacles shut these rewards off from entrepreneurial action, persons with the appropriate personality disposition will fail to function successfully, will seek other careers or quit the country.

25. This sketch of the psychological conditions of entrepreneurship has followed largely in the footsteps of Schumpeter and those influenced by his views on the role of innovating entrepreneurs in economic development. The argument raised by Hagen and McClelland turns on the view that economic growth will occur only if individuals with characteristic entrepreneurial personalities appear in sufficient number; that is, if the appropriate motivations affect not merely a few persons, but penetrate deeply into all layers of society. According to this theory, the appearance of entrepreneurship on a mass basis can be explained as the result of two factors. First, it flows from a special historical situation in which new paths to higher social status are sought through economic achievement. Second, it is the result of the appearance in a society, with more than ordinary frequency, of persons with special personality traits; i.e., persons with unusually high achievement motivation.

26. McClelland and his students have shown that such persons existed at various periods in history when societies did undergo rapid economic development, and that not only these persons but the whole value system of the societies adopted a more intensive preoccupation with achievement. This group of scholars also has shown that the drive of these persons is a result of their family rearing. But the very fact that a substantial number of entrepreneurs appeared in societies in which a short time ago little or no such talent seemed to be available, makes one suspect that individuals with the required ambitious drive exist in all human societies, though they may not always make their impact felt with the same intensity. If economic development and industrialization are planned as goals of a society as a whole, would-be entrepreneurs will step into a very different environment from that which prevailed in the historical epochs which McClelland and his students, Hagen, and even Schumpeter have investigated.

27. In the developing countries we meet nations which have written the slogan of economic growth on their banners and are prepared to provide the most extensive accommodation to persons who wish and who can step into positions of entrepreneurship. Moreover, from the great number of traders scattered about the urban and rural areas of almost all developing countries, we may deduce that individuals who exhibit achievement-oriented personalities are available in developing societies. What is required is not so much the creation of new personality types, but rather the opening up of opportunities in the social, economic, and political environment, in the scale and impact of government services, and in the intellectual equipment and training of the persons concerned.

28. The application of rational principles of planning to the fostering of economic growth will usually be reflected in a mixed-economy; i.e., one in which

both government and private enterprise undertake parallel and combined efforts for the over-all economic growth of the nation. This pattern of cooperation and division of functions is appropriate to developing countries, because an underdeveloped economy cannot afford to be doctrinaire. It faces serious shortages of all kinds and it must, in order to experience economic growth, confront the serious business of getting things done—getting capital accumulated and invested in the most useful directions for economic growth. Given widespread backwardness among large masses of the population and urgent desire for economic development, the leadership of the government is essential to an economy which otherwise might remain almost completely stationary. This cooperation between public and private interests may have two results: on the one hand, all available means must be employed to encourage and enhance the rate and amount of savings in the economy, and, on the other, the most efficient channels must be used to allocate these savings among those branches of production in which the over-all net return to the economy will be greatest. It is within this context that a centrally prepared plan has manifold uses, and if such a plan is well conceived and based upon the existing moral and political rules of the society, it may have a crucial influence in the growth of the economy. But if the general moral and political rules of a nation recognize the right and, in fact, the necessity of private enterprise, the plan will be successful only if it makes due allowance for the exercise of private initiative in all or a large number of fields of economic action.

29. That it is possible to combine an over-all economic development program with the simultaneous encouragement of private enterprise and the fostering of an entrepreneurial class is abundantly demonstrated in the many cases on record in both developed and less developed nations. This does not mean that frictions will not arise between the business community and the planners. There will be conflicts over the merits of short-term gains as against maximum long-term growth rates; the division of decision-making functions between public and private agencies; the precise limits of what industrial functions should be reserved to the government. Though—as was pointed out earlier—the business leaders will want and must get some access to the realm of political decision-making, they must learn, on their part, that a governmental development plan is not an instrument which robs them of all freedom of action. It merely designates, from the point of view of over-all economic considerations embracing the society as a whole, the paths of progress and the primary patterns of investments which are considered most conducive to progress in the economic performance of a society. This will imply regulations and even restrictions on the free exercise of entrepreneurship but may nevertheless conform to the long-run interest of many entrepreneurs, since in many developing countries the differences between social costs and benefits, on the one hand, and private costs and benefits, on the other, are often substantial.

30. These remarks are intended to reconfirm the fact that entrepreneurship can play a vital role in a planned economy of a developing country, provided the development plan is drawn up in such a way as to provide room for the operations of private entrepreneurs, and provided these entrepreneurs are not dismayed or

frightened from making independent decisions even though many decisions relating to production and investment are reserved for, or regulated by, government. It is quite conceivable that the mixed economy as it takes shape in many developing countries, may grow gradually into a new form of "economic system" with its own distinctive characteristics, one of which would be collaboration between public officials and private entrepreneurs in the development of the economy. The ultimate outcome most highly prized by both public officials and business leaders in a developing nation is economic development. Growth and improvement in the performance of the public sector stimulate demand for the output of private entrepreneurs. Also increase in output and improvement in the quality of goods and services supplied by private firms adds to the standard of living and the material welfare of the population at large. Hence, from a secular viewpoint the interests of government, of the newly emerging entrepreneurial class, and of the mass of the population in a developing nation are closely parallel. The main problem is to find a formula by means of which this parallelism of interests can be put into effect with least friction and greatest likelihood of success.

Improving Public Management in Newly Developing Countries

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1. The importance of public management to national development is less generally appreciated than some other developmental prerequisites. Good public management, nevertheless, is vital to development. If other prerequisites are present to a sufficient degree, and if public management is generally good, then there will be developmental progress. If, however, other prerequisites are present but public management is poor, there will be appreciably less progress and perhaps none at all.

2. Public management is concerned with the way in which government is organized, staffed, equipped, and supplied; the manner in which programs are planned, financed, executed, and reviewed; and with the procedures, systems, and methods employed in accomplishing work.

3. Good public management would be characterized by a governmental establishment in which appropriate functions of government were fully represented and systematically arranged in the structure of government. Functional assignments to governmental agencies would recognize the importance of the private sector of the economy and provide for its stimulation and control. Enterprises that could be effectively developed under private ownership and management would be excluded from the governmental structure. Lines of authority and responsibility would be clearly delineated throughout the governmental organization; and means of executive communication and coordination would be well developed. Staff services to management and facilitative services for line operations, including financial administration and accounting, planning, budgeting, personnel administration, and procurement and supply services would also be well developed. Continuing attention would be given to work procedures, systems, and methods in order that public business could be per-

formed expeditiously and economically by well-trained public servants. An effective field organization and local governmental institutions for carrying governmental services and activities to the grass roots of the country and population would exist.

4. Few governments can boast excellence in all of these areas, particularly governments of less developed countries. Public management capacity of such countries ranges widely: from some of the newborn nations that inherited little from their prior status in terms of public management experience to countries that, by virtue of their own history and devices or prior colonial status, attained a more sophisticated public establishment.

5. An approach to public management improvement in a developing country should be tailored to fit the prevailing situation. A comprehensive approach would be indicated for countries where public institutions were poorly defined and developed, while dealing with special, identifiable problems might suffice for more highly developed governments. It is important, however, that management improvement be undertaken with sufficient vigor and on a sufficiently broad base; otherwise, there may be no management improvement, with consequent weakening of national developmental efforts.

6. A comprehensive approach to management improvement would be characterized by the following. With full political backing, the highest executive authority of a country would order a broad administrative survey of the entire executive establishment. This survey, undertaken with expert assistance, would be similar in its purposes to the studies undertaken in Puerto Rico during the 1940's with such notable subsequent effect. The survey would ascertain the structure of government as it exists and, broadly, its proficiencies and deficiences. In consonance with anticipated governmental requirements the survey report would recommend improved functional alignments, the establishment of needed new agencies and as desirable, the consolidation or elimination of some existing agencies. If staff and service functions were poorly developed, the survey report would endeavor to place such activities in perspective as aids to good management and to seek to institutionalize means for their coordination and control. It should also seek to institutionalize, at an appropriately high governmental level, a unit to provide continuing attention, leadership, and stimulation to management improvement.

7. The initial administrative survey should be related to appropriate elements of the nation's developmental plan, if any, or to any planning studies and projections made, especially those related to public finance, education, manpower development, and training. If such studies had not been originated, they might constitute companion inquiries to the administrative management survey. To the extent possible, the survey report and recommendations should be realistic and realizable in terms of the government's future financial and staffing capabilities.

8. The report should be accorded executive and political attention consistent with its importance. Some of its more fundamental elements would require legislative action for effectuation; other parts should be permitted the flexibility inherent in installation pursuant to executive order. For example, the broad new framework of government would probably be prescribed in law; but details of internal organization and admin-

istration should be reserved to executive direction. Implementing orders should be accompanied by realistic timetables for accomplishment, and executive machinery should be established to assist, facilitate, and review progress toward stated objectives. A prime requisite to a successful program would be the selection of capable key officials to direct major organizational units. The chief executive should exercise much care in this selection process. Should it be necessary to appoint individuals of insufficient professional background for some posts, it might be desirable to backstop them by engaging professional caliber advisors. An intensive executive training program at this level in the governmental heirarchy should be undertaken leading to early sufficiency in terms of managerial capacity on the part of key officials.

9. The assignment of a portfolio to each key official should be accompanied by an outline program for management improvement in his assigned area. Over the years, but with review of accomplishments as aforementioned, the key executive and his staff would be expected to bring substance and vigor to the assigned management improvement outline.

10. Operating agencies might occasionally or frequently need technical assistance in matters associated with their operational programs. Such assistance should be directed principally toward institution building and training within the developing organization, and less toward performing operational work for the agency. It would be entirely proper for outside technicians to work side by side with local technicians as a means of training; and some demonstration projects would also be desirable. But wholesale reliance upon outside technicians to perform work that is properly the host government's would not contribute to institution building.

11. Some priority in the management improvement program should attach to developing staff and facilitative service functions within the government. These functions, including planning, budgeting, financial administration and accounting, personnel administration, and procurement and supply administration affect and involve all governmental elements. Each requires effective central coordination if the government is to function smoothly; but each also requires adequate technical performance on the part of operating departments in work related to the particular staff or facilitative service function. It would be well to develop at an early date capable central agencies to coordinate activities in each of the named specialized functional areas. These central agencies would then be able to provide stimulation, leadership, and guidance to operating departments in matters related to their specialty. Also, as these central agencies matured they could make available, through transfer, trained planners, budget analysts, accountants, personnel technicians, and procurement specialists to serve in operating departments.

12. Management improvement and attention to administrative problems and their solution, is a never ending task of good government. It is not sufficient to develop a plan for governmental reorganization and management improvement. The planning process must be superseded by continuing administrative analysis and action if the planned program is to become a reality.

13. The central staff agencies mentioned above, when organized, could do much to bring about orderly processes within their respective spheres of technical competence. Operating agencies, too,

as they developed, and as their staffs became better trained and more proficient, would be better able to cope with and solve management problems. But both staff and line agencies would require stimulation, counsel, and support in relation to management improvement. In short, the management improvement program should have leadership, coordination, and a central reservoir of expert assistance.

14. For these purposes many governments have found it desirable to establish still another kind of staff unit. Such units may be called by a variety of names: Office of Administrative Management, Organization and Methods Division, or Office of Administrative Research. Regardless of the name, the unit should be located organizationally at an appropriately high governmental level, perhaps in the central budget bureau or in the office of the government's chief executive. Its functions would be: to coordinate and oversee installation of the broad reorganization and management improvement plan; to keep such plan current with governmental growth and changing needs; to perform detailed administrative planning supplementary to the broad improvement program; to conduct organization and methods studies; and especially, to foster, promote, and facilitate the development of a growing competence on the part of all governmental departments to attack and solve their own administrative problems.

15. It would be well if such a unit could be organized in conjunction with the original management survey of the government—its staff working with or as members of the management survey team. This would afford excellent training for the unit's staff, which would probably be, at first, inexperienced in administrative management. Whenever it is organized, be it at this early stage or later, the unit should seek to secure the best qualified personnel obtainable as management analysts. Prior training in public administration would be highly desirable if not essential, and supplementary training in accounting and statistics would also be beneficial.

16. Upon the unit's organization, original staff members should be given intensive training in organization and methods work; and this course should be updated and repeated for subsequent staff acquisitions. Courses covering details related to organization and methods techniques should also be given from time to time. This more formalized training should be supplemented by practical field experience on studies conducted by the central management unit. As operating departments acquire organization and methods technicians of their own, they should be encouraged to participate in the training program of the central management unit. The endeavor should be to develop not only a cadre of capable technicians for the central management unit, but also to develop the capacity of line departments to perform organization and methods work of their own. Some interchange of technical personnel between the central unit and line departments could have a beneficial effect.

17. It is important that the central management unit establish a good library as a resource of the management improvement program and for training purposes. The unit might also find it desirable to publish a bulletin for general circulation in the government, which would have as its objective stimulation of interest, on the part of executives, supervisors, and public employees, in management improvement and in modern administrative methods, systems, proce-

dures, and techniques. An adequate filing system should be developed for the custody of materials relating to the organization and administration of all government departments and for the projects which it conducts.

18. It is not necessary here to discuss the management unit's survey program or the mechanics of Organization and Methods surveys. A wealth of information is available on these subjects. Competence in its survey and installation efforts, however, will be the unit's best guarantee of success.

19. The central management unit can be most effective if it can achieve a position of prestige and stature in the power structure of government. It should seek to reserve, establish, and maintain such a position, and it should use its influence wisely and strategically for the advancement of good administration and good government.

Skilled Manpower Training to Support Industrial Growth in a Developing Nation

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Introduction

1. This is a report of the techniques which proved effective, as well as those which were not so satisfactory, in the implementation of a vocational education project in Thailand. Through a presentation of specific details, an attempt is made to suggest advisable techniques for the education of skilled manpower in a developing nation.

2. A question may be raised whether Thailand is a typical example since it has made rapid strides in development, and is relatively rich.

3. The project on which this report is based was implemented through a contract between International Cooperation Administration (now the U.S. Agency for International Development), the University of Hawaii, and the Thailand Ministry of Education, Vocational Division.

4. Support has been given by United States Operations Mission, Thailand in the same manner other USOM project contracts have been supported in the Foreign Aid Program. The contract was signed on November 6, 1958. Two months later on January 9, 1959, three of the University of Hawaii staff members were in Thailand at work; seven additional staff members arrived in June 1959 for a two-year tour. The contract carried a provision for the University of Hawaii to purchase all equipment needed. The project consisted of the development of a national program of vocational education through the conversion of a number of already existing Carpentry Schools to Trade and Industrial Schools. At a later date, it was determined that eighteen centers would be established and a recent extension to the contract included a nineteenth center and a permanent Teacher Education Institution.

Some Basic Considerations

5. Industrial training in Thailand proceeded on several levels. One industry started with a basic staff of imported technicians who trained local employees at all levels. Another started with electronically controlled machines approaching automation. Typical of the high level mechanical equipment approach

were two industries recently established in Bangkok to make lightbulbs and flashlight batteries.

6. A question to consider in planning a program for training craftsmen is whether to transplant procedures developed elsewhere or whether to develop procedures based upon locally available materials and personnel. Either course presents difficulties. The transplanted program demands immediate importation of many items not available locally. The use of domestic resources reduces cost and utilizes local experience and information but curtails the activities possible by importation.

7. If a program of training is to be developed in a part of the world where another nation has been active, it will be necessary to give consideration to the methods of instruction previously used. There are several ways of proceeding in the devolpment of a National Program. For example, the development of machine tool operators or the training of a general mechanic in lieu of the development of workers to do one step in a manufacturing process may be considered alternative methods of approach. Whereas, one technique may be to train in the machine shop, for example fitters and turners, another system is to train an overall general machine shop mechanic. The general machine shop mechanic's training may cover the use of drill press, lathe, milling machine and power equipment as well as training in welding and some basic electricity. A portion of the time given to training for auto mechanics may involve basic machine shop training, welding and electricity. This is based on the fact that newly developing industry does not know what it will need and diversified training increases employment possibilities.

The Climate in Which the Program was Developed

8. In a recent (May 24, 1962) presentation to the Bangkok rotary, Nai Chalong Pungtralsul, Secretary-General of the National Economic Development Board spoke on the present 6 year development plan for Thailand:

At present, Thailand has a 6 year economic development plan, which is in the second year of operation. The main characteristics of the plan can be summarized as follows:

First, the planned activities consist of the developmental efforts in the public sector only. It leaves untouched the majority of economic activities which remain in the private sector.

Second, the planned activities are those that have already been undertaken by the government agencies. The necessity of this approach is obvious. One cannot immediately stop undesirable undertakings, and at once start on desirable courses, without having time for adjustments which may take as long as one, two, or even three years.

Third, the plan emphasizes agricultural development for the obvious reason that agriculture is still the base of economy. It is believed that more overall benefits would be gained by starting off from what we have in mind. Thus investments in power, roads, irrigation, etc. are justified on the basis of their contribution to agriculture. Growth of industry is left to private initiative, with the government providing encouragement as appropriate.

Their characteristics are not a matter of choice. They are dictated by circumstances. One cannot say today let us have a plan and then expect a plan to appear and to be implemented overnight. To be able to plan and to implement a plan at least two general conditions must be met: First, there must be a suitable administration set-up and, second, the people must understand the plan and be ready to participate in the planned activities. In the absence of these conditions, the first efforts, therefore, have to be simple, cautious, and practical. And this is the environment under which the 6 year plan was born. We may set many targets and formulate many projects in the present plan, but most of these should not be too difficult to reach and they should be the things that we are familiar with.

9. Nai Chalong's statement regarding agriculture remaining a base of the economy is evident in the recent importance of corn production. In 1961, 360,000 tons of shelled corn were exported to Japan. (Bangkok World, July 12, 1962). In dollar value, corn was third of the top six items of export. However, rice and fiber (jute) continue to be in the top six export items along with teak, rubber and tin.

Location of Training Centers

10. The nation has been divided into twelve educational districts. In each a General Education Development Center has been established for the up-grading of the total educational program. American technicians of USOM/Bangkok staff are working with this program. This pattern was followed and Trade and Industrial centers have been established in eight of the twelve General Education Communities. Centers of population were included such as Ubol, which has over 1,000,000 people in the Changwad. (There are 71 Changwads in Thailand). Localities near or at the places where large developments are planned, such as the Yanhee Dam at Tak, the Mekong River Project at NongKai and Nakorn Phanom were considered. Availability of natural resources and their development, such as tin mining at Phuket, were weighed.

11. The Vocational Department of the Ministry of Education supplied data and advice pertaining to the availability of buildings, personnel and the possible coordination with existing programs and anticipated activities sponsored by other agencies and other nations. Further consideration included the spreading of the new type of training, so that each center could serve as an area vocational school providing a reasonable opportunity for all youth of the nation to have access to this type of training.

12. From the surveys made, the following data were prepared:

Table I. **Criteria for Selection of Provinces for Comprehensive Survey*

Centers	Factors: Industry in the area (amount of)	Military in the area (needing skilled workers)	Project development in area (such as power or industrial plant)	Existing industrial school (school plant)	Access for supervision	Attention of headmaster	Capability of teachers or availability of competent teachers	*Rating scale* 5..Very high 4..High 3..Average 2..Low 1..Very low
	x1.5	x2.0	x1.5	x1.0	x1.0	x1.0	x1.0	Factor weights
	Weighted scores							Total weighted scores
Rajburi	6	6	1.5	4	5	4	4	30.5
Nakornsawan	3	6	1.5	3	5	4	4	26.5
Pattalung	3	2	1.5	2	5	5	4	22.5
Prachinburi	3	6	1.5	1	5	4	3	23.5
Ubol	3	6	4.5	2	5	4	3	27.5
Cholburi	7.5	2	7.5	1	5	3	3	29.0
Tak	6	2	4.5	2	4	4	4	26.5

*From Table 1, pg. 7, Report of a Trade and Industrial Education Survey of eighteen selected Provinces of Thailand, July 7, 1959, under the direction of Dr. Eldridge Plowden, Vocational Education Administrator, USOM/Thailand.

13. The final selection of center location was guided by the advice and desire of the Ministry which gave due consideration to the findings of the surveys and other information available to them.

Philosophy

14. After due consideration, a philosophy to guide the development of the National Trade and Industrial Education Program was evolved. It includes the following factors:

(a) The large majority of youth are up-country, outside Bangkok, and have had no exposure to any industrial trade training and an extremely limited contact with machine tool trades or industrial procedures. To reach these youth, centers for training must be established up-country.

(b) Data available do not indicate areas in which reasonably large numbers of highly specialized mechanics could be absorbed. The training offered should be diversified and meet the basic needs of industry for beginning employment.

(c) The elegibility age and level of training should be such that upon completion participants will be of age to enter employment.

(d) So far as possible the training should not only prepare for employment, preferably as an apprentice, but also serve as preparation for entrance into other training programs to attain higher technical ability.

(e) The training programs developed should be the basis for a National Vocational Program to be incorporated into the educational program of the nation under supervision of the Ministry of Education.

Training Courses

15. To determine the occupational fields for which training should be offered, the following were given consideration:

(a) The program was to be established in the Carpentry Schools. There is an abundance of wood throughout the nation. Developments under way, such as, the Yanhee Dam, extensive irrigation in the northeast, bridge and highway construction all require concrete form building. The general improvement of housing throughout the nation also calls for woodworkers. On the basis of these points, power woodworking equipment and tools for cement work, brick laying and plumbing were allocated to each center for the establishment of Building Construction Shops.

(b) A large portion of the nation is served by trucks and busses. The construction of highways has resulted in a rapid increase in the number of motor vehicles. Reports gathered from private and government agencies indicated a lack of capable auto mechanics. One equipment importing firm reported 5,500, four-cylinder diesel engines of a particular make had been imported into Thailand for use in pumping water, generating electricity, operating saws and for use in motor vehicles. Such information led to the decision to establish a combined auto and diesel mechanics training program in each center. Confirmation of the growth of the number of registered vehicles has recently been established: the 1962 registration of motor vehicles in Bangkok alone totals 79,750. In 1947, the number was 5,471. One of the American oil companies located in Bangkok reports a 15 percent increase in the sale of diesel oil this past year.

(c) Surveys made by the Ministry of Education, assisted by an American technician, in the eighteen selected communities scattered throughout the nation, (five in the south, three in the central region, six in the north and three in the northeast) gave some evidence of industrial potential. Every community surveyed had a number of small metal shops, some with heavy machine tools and many doing light metal work and welding. This information indicated a need for training in machine shop, sheet metal, and welding occupations. These activities were included in a program establishing a machine shop as one activity and combined welding and sheet metal work as another activity in each of the centers. Thus, it was determined to establish four basic shops for each of 19 centers. The belief that these trades are basic to all industries may have influenced the selection.

(d) In certain localities there was a need for electrical workers. One community surveyed was found to have 1100 small motors and such electrical devices as irons and cooking equipment. Another community on the periphery of the two television stations in Bangkok has more than 4,000 television sets. While an accurate count was not made of radios, each community has one or more radio stores and repair shops. On the basis of this information, basic electricity and radio shops were established in nine of the nineteen centers. The radio shops established in the centers have also been developed as a two-way radio station on a network with a frequency assigned by the Ministry of Communication to the Ministry of Education for educational use. This network, consisting of ten stations, has been of great psychological value in the development of a feeling of belonging to these almost isolated centers. The central station is located in Bangkok at the new permanently established Trade and Industrial Teacher Education Center.

Developing a Staff of Teachers

16. The project was considered more manageable when working with approximately half of the schools at one time. Thus, eight centers were selected composed of two each in four districts of the nation. The geography of Thailand indicates the possible physical division of the nation into four districts. The north and the northeast are divided by a range of mountains over which there is, at present, no means of transportation by rail, highway or commercial airline. The southern part of Thailand extends down the Malayan Peninsula for approximately one thousand miles south of Bangkok. The fourth district is the area around Bangkok.

17. With the selection of the eight centers, consideration was given to the staff already assigned to them. It was found that a ratio of one staff member to ten students was common throughout the program. Due to this low ratio, additional positions could not be provided.

18. The nation has a well established Civil Service System with employee tenure. Therefore, teachers already assigned had to be trained to take on the new teaching responsibilities.

19. The Director-General and the headmasters of each center conferred and assigned staff members to the project. In some instances, teachers were found with a limited amount of technical training in one of the occupational training areas. Only a few had practical experience in one or more of the occupations to be taught and that was of a limited nature.

20. Fortunately, the staff consisted of men who had worked with their hands and had no aversion to doing so. It was fortunate that these staff members were shop teachers and without exception eager to be included in the project program.

21. Centers were in rural communities and the staff members assigned were, in general, men with homes in the community where they were teaching. It was desirable not to disturb their willingness to stay in rural communities and it appeared advisable to avoid establishing the overall training center in the city of Bangkok. After considerable searching, a small new school with classroom buildings and a shop building on the outskirts of Bangkok at Wat Thepnari, Dhonburi was selected for training teachers in the skills that they were to teach. Part of the classroom building was used for a dormitory. A unit of equipment identical with that used in the schools (as to power and hand tools) was acquired through requisition by the University of Hawaii.

22. At the Teacher Development Center for the SEATO Skilled Labor Project at Wat Thepnari, Dhonburi each of the ten American technicians on the University of Hawaii Contract staff accepted the responsibility of imparting to the one or more counterparts, all of the information and skill possible pertaining to his particular assignment. The Director-General selected and assigned up to 100 full-time Thai personnel to work in each aspect of the programs. Each American technician taught his specialty, demonstrating and speaking in English assisted by his counterpart, speaking in Thai. Minimum lecturing and maximum demonstrating was stressed.

23. The training of teachers for the eight centers started by uncrating and setting up machines. It continued by establishing power connections, building work benches and tool cabinets. Then each shop member was exposed to the curriculum he was expected to teach students. Progress charts, instructional material and visual aids were constructed by each student-teacher to take home and use in his teaching. The group received 7 months training, 8 hours a day, 5 days a week. Saturday was free for individual work on the equipment and developing teaching aids. Of the original group of 45 teacher trainees, 43 are still teaching after two and a half years.

24. During the time teachers were being trained, shop buildings were converted at the eight centers, power lines installed and the equipment secured and delivered. As soon as the first group of teachers returned home, they began to establish shops using student help. Within two months, classes were in operation with over one hundred students in training in each of the eight centers.

25. At the time counterparts were selected to work with American technicians, a group of five participants was also selected to go to Hawaii for observation and skill training. These persons had some knowledge of English. Of the group, two were able to work as interpreters to assist the less understanding. Six months were spent in the Technical Schools of Hawaii observing and working with the staff members of the State Technical Schools. It is the opinion of the American technicians that money spent on these participants produced more (dollar for dollar) than any money spent. Upon their return, which coincided with the completion of the first period of teacher training, the participants were assigned as assistants for teacher training. Thus, they freed Thai and American personnel for travel up-country to work with staff members of the first eight centers during the time that the latter were involved in establishing their own shops. Frequent visits to the centers, made available technical help, and gave encouragement. Many small problems were solved before they had a chance to affect progress.

26. The second group of teachers for the remaining 10 centers was exposed to an identical program except for the establishment of the Teacher Training Shops which had been accomplished with the first group. Only a description could be given of the details of uncrating, assembling and setting up equipment. Actual experience was lacking. Upon return to the respective schools considerable fumbling resulted and there were some delays of several months. Another month spent in setting up one of the schools as a training project would have been profitable.

The Training of the Third and Fourth Group of Teachers

27. One teacher for each of 71 shops installed under the original provisions of the contract was supplied by the first two groups of teachers trained. To provide for 18 new shops, a third group was instructed in teaching shop subjects.

28. At the request of the Director-General, a group of 140 student teachers was enrolled under Thai instructors. These instructors were mainly shop teachers who had served as counterparts during early training. Thus, a permanent teacher education program for trade and industrial shop teachers was started. Contract extension includes assistance to this

phase of the work and the establishment of a permanent teacher training institution.

29. The use of teachers already located in rural communities has proven most satisfactory. Of 140 staff members given training for specific positions, one died, one returned to college, one has been promoted to Headmaster of one of the centers and one has been lost for unknown reasons. This left 136 who continued with the project.

30. One of the easiest ways for an individual to attain social status in this part of the world is to become a civil service employee. Even though the pay is small, life time security, and eventual pensioning have great attraction. For these reasons there is no difficulty in securing teacher student candidates nor in holding teachers after completion of training in a vocational field. Any one of the auto shop teachers could secure employment at double his teacher's wages but they all prefer to remain teachers. However, many teachers have outside employment and the time is soon coming when the temptation of higher earnings may change the picture.

31. None of the group is as well trained as he should be but all are receptive to suggestions, attend in-service programs and are given other assistance. During the period of preliminary teacher training a practical curriculum for each shop activity was developed involving both Thai and American technicians. After the teachers returned to their respective schools a monthly bulletin was sent from the teacher training center. Each issue carried additional curriculum projects, drawings and ideas gathered from all parts of the nation. From this effort has come text material published in English and Thai for Auto Shop, Arc Welding, Gas Welding and Sheet Metal work.

32. Early in the teacher training period, the respective headmasters and Changwad Education Officers were convened at the Teacher Development Center and briefed on the projected plans of the program, the equipment they could expect to receive for their schools, building conversion costs, and the amount of assistance available for instructional supplies during the time of the contract. This proved to be most valuable since communication between the Central Administration Education System and local community officials could have been the weak link in the establishment of a national program. In some instances this was the first contact the Changwad Education Officer had with the Carpentry School of his community. Interest through understanding on his part was considered to be a necessary step in the development of the program in his community.

Equipment and Power Installation

33. Provisions made in the contract allowing for procurement of equipment by the University proved to be of great value in saving time and costs. Equipment for one complete unit intended for teacher education arrived in Thailand and was in use just 6 months and 15 days after the first team members arrived in Thailand. A short delay in clearing equipment through customs was experienced mainly due to a lack of advance bills of lading. Paper work requiring the attention of numerous individuals and approval of two ministries was eventually coordinated by the Thai Technical Committee and recent shipments have been cleared within a few days after arrival.

34. To facilitate the handling of such a quantity of machines and tools, a local shipping company with an importer's license was employed. This company has provided trucking, storage and packing for shipment up-country. This use of local help has not only avoided waste of technician's time but has facilitated safe delivery of commodities. Equipment for the first eight centers was put in place just one year after arrival of team members in Thailand. Experience with procurement through other means indicates that not less than 2 years are necessary for delivery after specifications have been written.

35. Two factors were considered in selecting equipment:

(a) The installation was to prepare youth for industrial employment and should not be of a nature that could replace private industry in any community. A certain amount of production control is attained by size of equipment.

(b) The cost of the equipment was controlled to allow the establishment of as large a number of student work stations as possible. Thus, a happy medium was sought: sturdy equipment to meet instructional needs and to undertake production jobs. Costs per student work station for equipment and hand tools was approximately $400. Equipment was located in those centers where the program would be enhanced by meeting some of the needs of the communities.

36. The installation of equipment required planning to secure adequate sources of power. Thus, it was anticipated that at least six diesel generators would be needed for communities without sufficient power. Fortunately, as the project got underway, the Electric Organization of Thailand was developed and more than 100 of the municipal utility plants were placed under the supervision of this organization. Considerable assistance was secured in working with the management of the Electric Organization of Thailand, creating interest on their part for the use of power during the day when other community demands were slack. In several instances, new diesel generators were installed primarily because of the requirements of the school and in anticipation of industrial demand in the community. The result was that the municipal plants provided sufficient power and there has been no necessity to establish diesel generators at any of the nineteen centers. The problem of fluctuating voltage has persisted mainly due to hand operated controls in the local plants. Through the use of 3-phase motors damage due to fluctuations has been held to a minimum. To secure 3-phase power, it was necessary to stand the expense, in whole or in part, of a third line from the power station to the Vocational Center. This cost, obviously, is not as great as the cost of establishing five or six generators.

Selection of Students

37. The lack of exposure on the part of most students to any phase of the machine tool trades led to the development of testing materials for student selection. It was not considered adequate to use an interest inventory or a mechanical aptitude test.

38. After making a study of the curriculum to which students had been exposed, two tests were devised. One was in the field of mathematics and the second was in science. The latter utilized drawings which would indicate some

understanding of mechanical devices and, perhaps, potential aptitude. For example: a gear train indicating the motion of one gear and requiring the student to indicate the direction the other gears would turn. The end result of these tests was that the more capable students, in terms of mathematical ability and elementary science comprehension, were selected for training.

39. It is common practice for students to compete for entrance into school programs and for those who fail not to question the decision. Entrance examinations for all educational programs at the same level are given on the same day. Therefore, students desiring entrance to a program have to decide where they shall compete. The new vocational school was, therefore, in competition for students with other educational institutions. In some communities Teacher Training Institutions, Technical Institute and Agricultural Schools offer an opportunity for students on the same academic level. In four of the established communities, technical institutions have been developed offering entrance to students of the same academic attainment.

40. Since young people had little opportunity to learn about the vocational areas offered in the recently established centers, and especially because of the great attraction of Civil Service employment to graduates from the teacher education schools, the students competing for entrance to the Vocational Program were not, in general, the better students, or the students who felt capable of making a good grade on the entrance examinations of the other institutions. However, awareness of greater chance for successful entry into the Vocational Schools appeared to attract a number of students. In 16 of the 18 communities, a much greater number of students applied than could be admitted so that there was some possibility for selection. To assist in creating interest in the new program small hand bills were printed in Thai, illustrated with pictures of students at work in the various shops, and distributed generously in each community. Each year an increasing number of applicants has appeared.

41. Ten years of education are required for eligibility. The average age of new students is 17. Twenty-five students are selected for each shop. During the first year students are rotated through four shops, nine weeks in each. They are given a test at the end of each period to indicate areas of interest that they might be advised to follow during the second and third year.

Development of Guidance Personnel for Each Center

42. As the skill training of personnel continued, one staff member from each center was selected and given some training in testing, record keeping and counseling. A cumulative record file was developed for each student which for the first time in these schools brought together pertinent data on individuals in the program. This program has created considerable interest on the part of administrators and staff members of general education schools.

43. Personnel assigned to counsel students were assisted in making informal surveys of the community served by their respective schools. A list was made of garages, service stations, small shops of all kinds, industries and commercial establishments. A count was also attempted to ascertain the number employed, type of work, and training needed

for employment. Thus, each school has an informal survey of the community's potential for employment of youth and a guide for curriculum development. In some communities, due to the aggressiveness of school personnel, part time employment programs have been established for youth in truck and bus body building shops, tapioca mills, jute mills, ice plants and auto repair shops. This use of students on a part time basis indicates a source of possible full-time employment opportunities for graduates (the first graduating class will be March 15, 1963).

Cost Control

44. The introduction of power equipment in schools which previously had only hand tools has created many problems. For example, electrical rates are very high and will continue to be high until several large electrical projects are completed. A four shop school will use a minimum of $75 worth of electricity per month, equivalent to 1,500 Baht. In an economy where a student can buy a lunch for one baht, this is a large sum.

45. One of the most appreciated power tools is the surfacer. Lumber which previously was surfaced by hand finds its way into the community school shop to be surfaced. The Headmaster understands that he must charge to replace knives and for possible regrinding (although each surfacer is equipped with a grinder) but many have trouble remembering power costs until they get the monthly statement.

46. The development of a technical training program is greatly affected by the availability of materials. The approach to training has to be made in accordance with what is available. For example: steel of a uniform carbon content is lacking, therefore, a basic course in heat treatment needs to be adjusted to the materials available. Wire of proper size or shape may not be available. Welding rods, acetylene and many other items needed for a beginning course were lacking in many communities. It was necessary to interest local merchants or shop owners to carry needed supplies or purchase in quantity and ship to each center. The use of local merchants was not wasted effort since each is a potential employer and customer. However, the problems of quantity purchasing and adequate credit needs to be given further study.

47. Many factors pertaining to cost were carefully weighed during the establishment of the program. The budget had to meet increased costs with the establishment of the special manpower training program. One arc welder may use as much electricity as four or five ordinary instruction shops. Acetylene generators established at the training centers can eliminate the cost of shipping acetylene from some central point. Such items as film projectors, tape recorders, records and film which deteriorate rather quickly in a tropical country need to be considered in terms of overall costs and, where possible, substitute devices used.

48. Usually when one speaks of training skilled craftsmen, the impression is gained that power equipment must be involved. This is not entirely true. A big step forward can be taken with hand tools alone. Many useable items can be made in training centers, including basic hand tools which may be manufactured as a part of the curriculum not only for school use but also for sale. A bicycle wrench made by a beginning machine shop student will be highly appreciated by his parents, friends and especially the student himself. Throughout the pro-

gram consideration should be given to the development of a curriculum including the production of as many useful items as possible. Chisels, hammers, and sheet metal vessels are other highly useful products which help the schools attain acceptance and status.

Supervisory Staff

49. The establishment of a Trade and Industrial Program in nineteen centers located at considerable distance from the central office of the Ministry of Education required the development of a supervisory staff. This involved financing, as well as staffing. To implement the program, one headmaster in each of the four districts was appointed by the Director-General for Vocational Education to act as a district coordinator. Each district coordinator continued to hold the position of headmaster of his respective school. In each case a competent assistant headmaster was appointed from the staff of the school.

50. Through assistance given by the United Kingdom a small Land Rover automobile was procured for two districts. A Jeep station wagon assigned by USOM End-Use Auditor from another project has provided transportation in the third up-country district. The central district has the use of a contract team car.

51. The American technician plans visits with the district coordinator and provides for Thai personnel attached to the project to accompany them, according to need. For example: if problems pertain to power and power equipment, a Thai electrical technician will be asked to accompany them. Five retrained teachers are functioning in this capacity and are also conducting short seminars for the shop teachers. The supervisory program is retarded because several capable young men do not have sufficient Civil Service status to qualify as supervisors.

52. Over 2,500 pieces of power equipment are involved in the program. Maintenance, repair or replacement of parts call for constant supervisory assistance. The administrative staff is greatly in need of continued help to program teachers and students, keep a steady flow of instructional supplies, deal with the community and investigate charges of competition from private business interests. Steps have been taken to prepare the staff to accept and to appreciate supervisory assistance.

Summary of Attainments and Some Observations

53. Certain basic social concepts need to be developed. It is important that there be a realization on the part of the general population and more specifically on the part of parents and youth, that a certain amount of academic knowledge is needed by the skilled craftsman. Recognition is also needed of the relationship of technical training and academic training and the necessity for respecting regulations. In a society where there is no opportunity for participation in activities which develop these appreciations, it is essential to recognize that their development takes time. In the United States, reference is often made to the development of school youth only one generation removed from foreign countries. In a developing nation it may take a generation to become accustomed to mechanical devices and power equipment.

54. Prior to the establishment of this project, there was no provision outside Bangkok for youth to secure training in the machine tool trades or to enroll in a technical institute. The 19 centers operating as Area Vocational Schools fill this need.

55. Except for the large government-operated shops in activities such as the railway system, there is no apprentice training in the nation. Some few beginnings in part-time employment for youth attending school have been made. The growth of tourism has brought about interest on the part of hotels to provide certain types of training in the service fields.

56. Creation of a pool of skilled craftsmen requires organized, coordinated effort. If it is to be a national program, it is essential that there be national legislation which will support the efforts of any particular ministry involved in the development of craftsmen. Legislation is needed not necessarily to command but to support and to unify the effort by regulating the elements which protect both the worker and the employer and to assist the training agency. A training period should not be merely a time serving period. Regulations should be established which affect both the employer and the learner resulting in adequately trained mechanics acceptable by the industry. Essential legislation includes a minimum wage act, the establishment of a national employment service, financial support for the vocational education system or agency, apprenticeship laws and health laws.

57. Each project such as the one described can contribute only to a limited degree until the total activities pertaining to industrial development are coordinated nationally.

Some Aspects of Management and Skilled Supervision

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Introduction

1. There is widespread interest today in technical assistance that will contribute to the social and economic development of less developed countries. This activity has many facets for the student of management, public administration or business administration.

2. The purpose of this study is to analyze how some fundamental principles of American management have been applied overseas in the post World War II period, how they fit the needs of supervisors in less developed economies, and to evaluate how effective they have been in management development. This study is limited in scope to those techniques that are directed primarily to improving the skill of supervision at the first and middle management levels, although applicable to top management. The findings and conclusions, other than those cited in specific references, are based on the writer's experience as Regional Director of the Training Within Industry Service, War Manpower Commission, during World War II, subsequent participation in and observation of projects during assignment in the countries of Israel, Brazil, and Surinam, and, on a general review of industry projects on a worldwide basis during his current assignment in Washington.

Post War Experience Overseas—1946–1961

3. A considerable portion of the United States and the United Nations technical assistance programs abroad during the past 10 years has been concerned with problems of the management function in government and the private sectors of the economy.

4. This assistance normally consists of one or more of the following types: (a) direct hire technicians, (b) individual consultants, (c) top level seminar teams, and (d) university contracts. It is usually supplemented by individual or team studies for selected participants from the host country in the country providing the services. In addition to the specialized services provided through international agencies of government a considerable amount of management know-how is made available by foreign private corporations in carrying out their operations within a particular country.

5. As an example of (c) above, the Council for International Progress in

Management during the last 10 years, working for the Marshall Plan originally and now A.I.D., conducted a series of management seminars in 28 countries of the world.*. The purpose of these seminars was to examine and discuss with executives the potential role of professional management in improving the conduct of all kinds of enterprises involving organized effort, including government, educational institutions, business enterprises, labor unions, and non-profit organizations (1). These seminars represent a horizontal type of executive development at the top management level, rather than a vertical type that will reach all levels of management, and for the purpose of this study have little to contribute to improving the skills of middle management and the first line supervisors.

6. University contracts have been used extensively in several countries, mainly for the purpose of building up government institutions and schools of Public and Business Administration. For example, in Brazil, Michigan State University has provided a staff at São Paulo University since 1956 to establish an undergraduate curriculum in business administration. This work has been supplemented by graduate study on the Michigan State campus for prospective Brazilian staff members.

7. The Productivity Centers which have been established in many countries have utilized mainly direct hire technicians or short term consultants in planning services, and training host country personnel to carry on. Extensive use has been made of supplemental training for individuals or teams in other more developed countries. This type of assistance is also of long range institutional development type. When properly staffed, such centers can provide a vertical type of training for all levels of management in the three fundamental activities of producing, selling, and financing.

8. The larger foreign corporations, with operations in the less developed countries have to a large extent relied on expatriate personnel for top level management. Because of the shortage of skilled manpower and absence of institutions to supply trained managers or supervisors they have relied on intensive on-the-job training for first line supervisors and middle management.

9. A rather uniform pattern is followed in most of these countries to provide short, intensive practical training in the basic needs of the supervisor. Most of these programs are based on the body of systematized knowledge developed in the United States during World War II. These management techniques now form the core of the industrial relations and training programs in many of the larger companies in the United States and Europe and have been extended to many of their overseas operations. In the more developed countries of Europe and in Israel, Brazil, and Japan the government has sponsored the promotion of this training on a national basis, to meet the shortage of supervisors and skilled workers. This type of training offers several significant advantages in the less developed countries by providing vertical level training from top management down through the first line supervisors. Training is geared to short term immediate needs and not dependent on the time consuming, long range institutional

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*Teams of American management people were recruited under the auspices of the Agency for International Development and its predecessor agencies by the Council, an American, nonprofit, nonpolitical organization devoted to scientific management on the international level.

building process of 5 to 10 years duration. Because of the importance of this approach to the less developed countries, the essential characteristics of what is internationally known as the "Training Within Industry System" are treated under a separate heading in this report.

10. In the few less developed countries where this system has been successfully established and used, the writer has observed that the organization of management institutes, productivity centers, management societies and institutions of a more permanent nature have followed in the wake of such training. They are the result of development—not the cause.

11. However, there is a feeling among U.S. technicians who have served in the less developed countries that, in general, the sophisticated techniques of American management have not produced the tangible results that might be expected. There are definite ethnic, social and cultural barriers to the application of our concept of management principles. Some of the more important are treated under the heading that follows.

Ethnic, Social and Cultural Barriers

12. *The Elite.* Mr. Hagen in his paper for the Brookings Institution Conference on Research Needs for Development Assistance Programs has brought into sharp focus some social and cultural barriers to economic progress (2). In his discussion of the role of authority he points out that it has a significance to key officials in a traditional society different from its significance to a person from a Western culture in which rapid technical progress is going on. The typical top management official in less developed areas may have his authority, not because of his demonstrated capacity in the field, but because he has the proper background and has been educated at the proper schools. His authority thus is a symbol of his superior status as an individual. In some areas to delegate part of his authority to subordinates is to give up part of his status. To ask subordinates for their judgment before making a decision, or for factual information as a basis for decision, may imply that he is not worthy to bear authority since he must depend on subordinates. Doing so threatens the difference in identity between him and the subordinate. Hence, he will cling to his authority, not deliberately but unconsciously. His decisions concerning new functions will be authoritarian and often not responsive to the purposes to be served, objectively reviewed. Technical and scientific education or formal training in administration will have almost no impact on these inhibitions. Hagen treats this further in the case of key officials in less developed areas by saying that in an uncertain and somewhat hazardous world, the security offered by one's position within one's family, clan or other primary group is of especial importance, and to protect one's family and advance its interests may be a moral duty that takes primacy over any more general obligation to society. In pursuing this moral duty, the individual will often be, in Western terms, less sensitive to public interest.

13. For a number of years, scholars associated with the Inter-University Study of the Labor Problems in Economic Development have been investigating the relationship between industrialization, managerial leadership and wage earning groups throughout the world. The full conclusions of this research which has been recently published deals with the elites in five types that customarily and

variously take the leadership of the industrialization process (3). In general, their findings confirm the observations made by Hagen in regard to the dynastic elite of the traditional society. The four other categories that may emerge from time to time in the development of a country are namely: the middle class, the revolutionary intellectuals, the colonial administrators and the nationalist leaders. The study points out how these groups tend to break down the dynastic elite in the traditional society.

14. Myers in his study points out that management in many of the developing countries can be characterized as either authoritarian or paternalistic. This creates a climate in which competent middle management and upgrading of workers is difficult to develop (4).

15. *Industrial Organization.* The role of authority as discussed above is only one facet of the problem. Equally important is the fact that Western industry is highly inter-dependent. It depends for its efficiency on other industries. It assumes the availability of materials, components, and tools. It depends also on auxiliary enterprises which can provide technical, financial and managerial services on demand; on a complex network of communication and transportation facilities; and an intricate system of business practices. An industrialized economy is of necessity a technical complex, not a set of isolated pieces of technology. For this reason one piece cannot be detached from the complex and used efficiently in a less developed country without skillful adaptation.

16. The image, seen in many countries, of America's great industrial power and dynamic development attributes these developments to technical advances alone, without visualizing the central role management has exercised in getting results from technical proficiency and people possessing it. In most instances, technicians from less developed countries who receive intensive technical training in the U.S. fail to see the place of management in accomplishing major technical projects. Upon return to their respective countries they find that they cannot move ahead because they are unable to translate the fundamentals of American management to the peculiar indigenous conditions of their countries. A study of this problem has been carried out for foreign technicians in training at the Engineering Laboratories of the U.S. Bureau of Reclamation, Denver, Colorado. This led to the establishment in 1953 of a special course in the Fundamentals of American Management under the auspices of an inter-university group (5).

17. Another aspect of industrial organization is the size of undertakings in less developed countries. For example, in Israel in 1953 the Statistics Branch, Ministry of Labour reported that approximately 30,000 undertakings in all branches of economic activity had less than 50 employees, with an average of 4. Only a limited number, estimated at between 18 and 24, employed more than 1,000 workers. The small business firm, which is characteristic of the less developed countries, does not have the staff specialists necessary to carry out many management functions. The general manager becomes a jack of all trades. For this reason outside consultant services which attempt to install programs for developing supervisors or providing other technical services find a fertile field for operation. Mixed company courses meet the needs of the small company with one or two supervisors. The key point here is that training is needed not for the

elite top management, but rather to help top management develop the middle management and supervisory level. This is most important in what we call small business concerns of less than 500 employees.

18. *High Level Manpower.* The scarcity of competent managerial, scientific and technical personnel ranks high on the list of bottlenecks in the less developed countries. In any country the number of persons in the high level category is quite small. Harbison in his study reports that in Nigeria the total is less than one-tenth of one percent of the population. In more advanced countries such as Egypt or India, it might be over one-half of one percent. In the most advanced societies such as the United States, USSR or Germany, it might approach 3 or 4 percent (6). This raises some interesting questions about the feasibility of providing effective training in management where educational levels are very low and competent personnel exists only at the top level. Technical and scientific education or formal training in administration is applicable at present to only the top level. For the several reasons discussed here it will have almost no impact on cultural inhibitions in less developed countries with traditional societies.

19. *The Productivity of Labor.* In considering the ethnic, social and cultural barriers some thought must be given to the aptitudes, skills or attitudes of the total labor force, which is the source of managers. The only recent comprehensive study of the labor force in less developed countries was made in Africa by the International Labour Office. The findings are reported in the African Labour Survey (1958) (7). This study states in part: "There is no scientific basis for the proposition that any initial incapacity of the African rests on any difference in hereditary biological constitution between him and members of any other racial group. It must be equally accepted that existing inadequacies stem from certain factors of environment, including unfamiliarity with the tools of modern industry, gaps in education and appropriate training and in the background against which attitudes considered appropriate to industrial societies develop." In most developing countries, it can be assumed the worker in general is ill adapted by any conditioning he has received through his economic, social and cultural background for assimilation in a wage economy of the European or American pattern.

20. After consideration of these several important barriers to economic development it is timely to take a look at the "Training Within Industry System," which has been successfully used on an international basis for improving the skills of supervision.

The Training Within Industry System

21. *Background for Development.* The wide use of the Training Within Industry (TWI) Programs has been possible only because of the way in which they were originally developed. In the United States these programs for industry came from industry during the war years 1941–45, and represent the pooled experience of many people. The nation's war plants provided both the materials and the proving ground. A detailed explanation of the thinking and philosophy that went into the development of these

management techniques for improvement of supervision may be found in the Training Within Industry Report (1945) (8).

22. Each of the TWI programs came about through pressure to meet a specific need which was occurring in war plants all over the country. The programs were not developed with any thought as to the order of their importance or the order in which a plant might use them. In 1940 and 1941, industry was faced with the task of absorbing hundreds of thousands of new workers. For this reason the job instruction program was given priority attention. Shortly after work on this program was underway, managers were questioned as to the problems of their new supervisors, and supervisors themselves were asked about the fields in which they most needed help. Out of this survey of industrial opinion came the decision to do something in the field of improving methods (Job Methods) and in the field of working with people (Job Relations).

23. The use of the word "Job" in the names of the TWI programs was not an accident. Before any of these programs were developed, it was determined that whatever was done would have to be fundamental and simple. It would have to be part of everyday work for everyday supervisors at the job level. For example, "Job Relations" was chosen rather than "Human Relations" to emphasize the specific area in which it had been decided to work.

24. *Skills of Supervision.* As a result of the experience in developing the TWI programs a simple concept of the basic needs of the supervisor emerged. The statement which has become a standard part of the TWI thinking and publications, is:

Every Supervisor Has Five Needs

(a) Knowledge of the work—materials, tools, processes, operations, products and how they are made and used.

(b) Knowledge of responsibilities—policies, agreements, rules, regulations, schedules, interdepartmental relationships.

These two knowledge needs must be met currently and locally by each plant or company. Such knowledge must be provided if each supervisor is to know his job and is to have a clear understanding of his authority and responsibilities as a part of management.

(c) Skill in Instructing—increasing production by helping supervisors to develop a well trained work force which will get into production quicker, have less scrap, rework and rejects, fewer accidents, and less tool and equipment damage.

(d) Skill in Improving Methods—utilizing materials, machines and manpower more effectively by having supervisors, study each operation in order to eliminate, combine, rearrange and simplify details of the job.

(e) Skill in Leading—increasing production by helping supervisors to improve their understanding of individuals, their ability to size up situations, and their ways of working with people.

These three skills must be acquired individually. Practice and experience in using them enable both new and experienced supervisors to recognize and solve daily problems promptly.

25. The refinement of this concept during World War II, by collaboration of industrial concerns and educational institutions, under the auspices of the War Manpower Commission resulted in

a system of training that has been further refined during the past 10 years. The basic characteristic of this system is to assist companies in giving their supervisors a start in acquiring these skills through three 10-hour programs in Job Instruction, Job Methods and Job Relations. The content of current versions of these courses as used in industry today is described briefly under the headings that follow:

26. *Job Instruction.* This program is a development of the instructional steps developed by C. R. Allen in World War I (9). They have become a standard for the training of trade teachers in vocational education. The refinement of the course during World War II is reflected in the current version used by Esquire, Inc.:

How to instruct

Step 1. Prepare the Worker—Put him at ease. State the job and find out what he already knows about it. Get him interested in learning the job. Place in correct position.

Step 2. Present the Operation—Tell, show, and illustrate one IMPORTANT STEP at a time. Stress each KEY POINT. Instruct clearly, completely, and patiently, but no more than he can master.

Step 3. Try out Performance—Have him do the job—correct errors. Have him explain each KEY POINT to you as he does the job again. Make sure he understands. Continue until YOU know HE knows.

Step 4. Follow Up—Put him on his own. Designate to whom he goes for help. Check frequently. Encourage questions. Taper off extra coaching and close follow-up.

IF THE WORKER HASN'T LEARNED, THE INSTRUCTOR HASN'T TAUGHT

How to Get Ready to Instruct

Have a Time Table—how much skill you expect him to have by what date.

Break Down the Job—list important steps. Pick out the key points. (Safety is always a key point.)

Have Everything Ready—the right equipment, materials, and supplies.

Have the Workplace Properly Arranged—just as the worker will be expected to keep it.

27. *Job Methods.* The principles of this course are based on work in the field of scientific management which has been carried on in industry since the turn of the century. The current version as used by the Shell Company is a simplification of techniques used in methods engineering work to the extent that they can be applied by all supervisors:

How to Improve Job Methods

A practical plan to make better use of available manpower, machines and materials.

Step 1. Analyze—Watch the job being done—list all details. Note snags and difficulties.

Step 2. Challenge Each Detail—Why is it done? Is it necessary? Is there a better way? When? Where? Who? How? Note all ideas.

Step 3. Develop—Review ideas, eliminate—simplify—combine—rearrange details. List details of improved methods.

Step 4. Introduce—Submit for approval. Convince and train users. Check results.

Use These Aids. Always enlist the help of those doing the job. Work out your ideas with others.

Safety—Is it a safe method? Are current safety rules adequate? Can it be made foolproof?

Materials—Can better, less expensive or less scarce materials be used? Can scrap or waste be reduced or used for another job?

Equipment—Is your equipment correct, fully used, and in good working condition? Is other equipment available within the organization? Can holding devices be used? Can gravity aids help?

Design—Could improvement be obtained by alteration of design of product or equipment?

Layout—Is space being used to advantage? Is everything in the convenient work area? Can both hands do useful work?

28. *Job Relations.* The Job Relations course was developed by the TWI Service over a two-year period of research and experiment from 1941 to 1943. There was no precedent for a method in this field. The current version of the content of this course as used by Esquire, Inc. is as follows:

How to Handle a Problem. Determine Objective

(a) Get the Facts. Review the record. Find out what rules and plant customs apply. Talk with individuals concerned. Get opinions and feelings. Be sure you have the whole story.

(b) Weigh and Decide. Fit the facts together. Consider their bearing on each other. What possible actions are there? Check practices and policies. Consider objective and effect on individual, group, and production. Don't jump to conclusions.

(c) Take Action. Are you going to handle this yourself? Do you need help in handling? Should you refer this to your supervisor? Watch the timing of your action. Don't pass the buck.

(d) Check Results. How soon will you follow up? How often will you need to check? Watch for changes in output, attitudes, and relationships. Did your action help production?

Foundation for Good Relations

A Supervisor Gets Results Through People

Let each worker know how he is getting along.

Be sure you know what you expect of him. Point out ways to improve.

Give credit when due.

Look for extra or unusual performance. Tell him while "it's hot."

Tell people in advance about changes that will affect them.

Tell them WHY if possible. Get them to accept the change.

Make best use of each person's ability.

Look for ability not now being used. Never stand in a man's way.

People must be treated as individuals.

29. *Relation to Current Management Thinking.* For the purpose of this study it is necessary to relate the TWI system to current thinking in the field of management. Terry in his book on the *Principles of Management* gives recognition to this program in the chapter on Supervision. He rates the TWI program as excellent, and among the best available (10). However, he treats the separate courses in a superficial manner and one must go to the TWI Report or individual company practice for a good understanding of the development of these techniques, their use and results. It is important to note that in all of the TWI

courses fact finding and an analysis of facts are basic. In the Job Relations program a problem solving technique is involved. The basic principles reflected in the TWI programs are incorporated by Terry in his chapters on *Managerial Decision Making, Creative Thinking in Management, The Science and Art of Management, Policies, Procedures and Methods, the Human Element in Management Motivation, Supervision, and Personnel Management.*

Analysis of Success Factors

30. Basically, the problem of human resources in less developed countries is no different than the one the United States faced during the emergency of World War II. It is logical to assume that what was effective during that period of time should have application to the current emergency of rapid change in the economic development of less developed countries.

31. To the writer's knowledge, no attempt has been made to determine why the TWI System has been particularly effective in overseas projects. An attempt is made here to make an analysis of the important factors that have contributed to acceptance and use:

(a) The system is one of utter simplicity.

(b) It has been prepared for presentation by an intensive and carefully blueprinted procedure utilizing a minimum of time.

(c) It has been built on the principle of demonstration and practice of learning by doing.

(d) The job demonstrations in the case of the Job Instruction and Job Methods are practical jobs selected by the supervisor from his own department. In Job Relations, the case studies are actual plant problems which the supervisor has to do something about.

(e) The courses are in simple shop terminology that can be translated without too much difficulty to the language of the host country and used effectively by bilingual trainers.

(f) The programs reach a level below the elite top management.

(g) The system provides the core and base for developing a more comprehensive industrial relations program. With proper application it points out the needs for vocational education, industrial engineering, suggestions system, selection of supervisors, operations manuals and changes in company policies.

(h) The program provides for a multiplier technique by training selected men or women as trainers.

(i) The 10-hour courses of the TWI program have been criticized as a "package" approach to supervisory training. However, teaching can be organized, and organized teaching is done in units called courses.

(j) What each supervisor learns is different. Learning cannot be organized. Each supervisor brings to his position his own unique background, education and experience. Out of these he has constructed his own theories and concepts of his role and function as manager. Progressively he learns from experience, and from time to time he is moved to alter his attitudes and managerial behavior. By this process he moves unevenly and uncertainly or not at all if he is lacking in imagination or motivation. It is in this area of ideas and experience that TWI courses play a significant role. This system provides an effective technique to change the climate in an organization in spite of the obstacles mentioned earlier in this report.

(k) Perhaps one of the most important success factors is a carefully worked out plan for management involvement and participation. The procedure to be followed in establishing the program in a company or group of companies is essential to tangible results. In the writer's opinion the success of the TWI System in a company is proportionate to the attention given to this matter.

32. A further analysis was made to reveal the extent to which the TWI System has been used in less developed countries. Accurate information was not available on this point. General information available shows that it is a phase of the U.N. Expanded Technical Assistance Program. In this experience, it has been found necessary to hire technical experts to establish the several programs in a country. In this respect considerable difficulty has been encountered in recruiting qualified technicians acceptable to the U.N. and the host country. Bi-lateral assistance has been provided by the British Ministry of Labour, Industry, and Commerce to some African countries. Private corporations both American and European have applied and used the TWI System in some of their overseas operations. Only limited use has been made of the system by the several United States Agencies concerned with foreign technical assistance, except in Europe under the Marshall Plan. The International Cooperation Administration assisted in establishing the system in Brazil, through the services of one direct hire technician; in Chile through an inter-agency service contract; and in Japan and Indonesia through contract services provided by Training Within Industry, Inc., Cleveland, Ohio. Technical bulletins titled Training Manuals for Job Instruction, Job Relations, Job Methods and Training of TWI Trainers have been distributed to all Missions by the former Technical Aids Branch, Office of Industrial Resources, ICA. The distribution of these Technical Bulletins has been ineffective in promoting the use of the TWI System. This is due to the lack of guidelines on how to launch the programs and conduct master institutes for the development of a cadre in the host country to carry on the work.

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The Development of Latin American Specialists in the Chemistry of Occupational Health

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Introduction

1. The Peruvian Andes, or legendary "Land of the Incas", teem with gold and other minerals which have been mined since pre-Colombian times. However, with the advent of mechanization and the increased demand for strategic metals during World War II, occupational diseases were bound to increase quantitatively in scope and nature. The economic corollary was and is, in any case, decreased productivity followed by increased medical compensation (plus other hidden costs), and/or labor turnover which can be critical in the continued progress of a less developed or emerging nation.

2. Consequently, when the incidence of "Pneumoconioses" among the miners of Peru reached alarming proportions in 1940, that government created a Department of Industrial Hygiene to cope with this problem. However, due principally to inadequate financial and technical resources, it was virtually impossible for this unit to materially reduce the existing occupational hazards.

3. The means to resolve these difficulties were obtained in 1947 by the enactment of Public Law 10833, followed by a request to the Institute of Inter-American Affairs (now a part of the Agency for International Development) for assistance in the organization of a new Department of Industrial Hygiene. Only the chemical phase of the operation will be treated in detail in this paper.

4. Industrial Hygiene, or more broadly speaking Occupational Health, is a public health discipline requiring the collaboration of a basic team composed of physicians, engineers, and chemists. The objective of such a unit is to effect the proper evaluation of and subsequent control or elimination of any existing occu-

pational hazards in agriculture, industry or mining enterprises.

5. Teamwork is essential to the success of this operation, since each phase of the discipline has important responsibilities, but the chemists do provide service to the other two units of the team. Thus, they analyze biological material for the physicians, and environmental samples for the engineers. The former data are essential (especially in legal cases) as confirming evidence of the worker's degree of intoxication by an industrial poison; whereas, the latter information is fundamental to the design of appropriate protective measures, and subsequent proof of the efficiency achieved in controlling the hazardous condition in the workers' environment.

6. The amount of toxic constituent which the chemist must be prepared to analyze ranges from the infinitesimal to macro quantities. For example, 8-millionths of a gram of lead per one hundred milliliters of urine, and 0.2-milligram of that metal per cubic meter of atmosphere are typical threshold limit values.

7. Obviously, the scientific prerequisites to carry out such analytical work include adequately trained personnel plus the availability of modern instrumentation, and access to a comprehensive technical library. None of these requirements existed in Peru prior to 1948 since even the Faculty of Chemistry at San Marcos University was not equipped nor prepared to effect micro-chemical analyses.

Initial Phase of Operation

8. The first course of action was to provide intensive in-service training to the available personnel with emphasis on the chemistry related to the major occupational risks to health. These risks had been broadly defined by a preliminary survey conducted in 1947 under the auspices of the Institute of Inter-American Affairs (1). Implementation of the recommendations in this report resulted in an assignment of the senior author to the Peruvian program, with the responsibility of developing the chemical phase.

9. Originally the duties were to design and equip the laboratory, train graduate Peruvian chemists in the required micro-techniques, supervise the translation of appropriate scientific and technical material into Spanish, and develop methods tailored to local requirements.

10. This initial phase of the operation was accomplished during the period of 1948–51 during which time four Peruvian trainees in chemistry were given in-service training. All of these technicians were "graduates" of San Marcos University in Lima, but none had initiated a thesis—which was the final requirement to obtain their degree. This was the normal situation which reigned in Peru during that epoch, but it did present an ideal opportunity to wean these candidates away from a customary cost-study of a hypothetical plant layout into an area of independent, if not profound, scientific endeavour.

11. In addition, the appropriate analytical instrumentation had been hitherto non-existent in Peru. Consequently, a fortuitous by-product of technical co-operation during the early 1950's was the indirect stimulation of the scientific approach and methodology in the preparation of theses for academic degrees. Eventually, this influence was extended to other Latin American republics—but in Peru alone, 10 student trainees received their degrees based on scientific investigations related to subjects on the applica-

tion of chemistry to occupational health problems.

12. Of the latter, one trainee prepared two theses including an advanced degree publication; another recently obtained a Ph. D. in Chemistry at an American university; whereas, a third became Acting Chancellor and Dean of the Chemistry Faculty at his former university in Colombia. These unexpected side-effects are a bonus that could not have been anticipated but are of such a nature that they perhaps constitute a more revealing, unbiased measurement of the contribution made by technical assistance to the development of the growing Peruvian nation. Thus the simple availability of instrumentation and guidance to a small number of essentially self-educated technicians provided the impetus for the creation of a cadre of professionally trained scientific personnel—personnel essential to the institution of the industrial hygiene program, both in Peru and other Latin American republics.

13. Subsequently, one of us (ASL) taught elementary courses in instrumentation at San Marcos University and such activity catalyzed the development of a university contract in chemistry between this University and the University of New Hampshire. The implementation of this project has resulted in an assured source of highly trained chemists, not only for the field of occupational health, but also for industry in general. The second author is still actively associated with this undertaking, as an assistant professor at San Marcos.

14. The basic training philosophy, originally introduced in Peru by the advisor, but subsequently extended to six other Latin republics, involved the utilization of two instruments as the core around which the industrial hygiene chemical laboratory was built. Thus, polarographic techniques were used for the analyses of atmospheric samples, and spectrophotometric methods were adopted for biological materials. The principal objectives were: lower analytical costs, known limits of accuracy, standardization of techniques, and ease of sample manipulation. This is especially from the viewpoint of having concentration ranges in the final solutions that could be expected to fall well within the optimal values for the instrument in question.

15. Therefore, it was not necessary to aliquot atmospheric samples since the sensitivity response of the polarograph could be selected at will to permit the determination of toxic constituents up to 15 times the threshold limits, as in the case of lead (2). Similarly, in most instances, the spectrophotometric method permitted the analyses of 4–40 micrograms of lead per 10 grams of blood within an established confidence limits but without having to concentrate this element.

16. A later additional benefit derived from the laboratory design and training technique was the facility of obtaining inter-laboratory evalautions of accuracy and precision—since operational parameters for the instrumentation (identical in all Latin American Occupational Health laboratories), and analytical procedures were established in the Peruvian laboratory, which served as a base of operations. Further, each new trainee, whether Peruvian or otherwise, spent 6 to 12 months in training using a monograph (3) that served as a standard reference source since no other literature of such a nature existed in Spanish.

17. The procedural approach mentioned was feasible since the problems that existed in the various Latin Ameri-

can countries were generally common to all of them. For example, as shown in figure I, two major analyses were lead in atmospheric or biological samples, and quartz in respirable dusts. The occupational hazard from the latter constituent was one of the critical Peruvian problems in 1950 (there was a 13 percent incidence of silicosis among miners which was reduced to 5.4 percent in 1960). It should be noted, however, that another South American republic still has a serious silicosis exposure that imposes a burden on its national budget for indemnification and medical care for its miners, plus other hidden costs, especially in terms of lost productivity and decimation of its pool of experienced human resources.

18. The scope and volume of analyses for lead and quartz warranted an effort to keep the respective methods under statistical control. This was considered important because: (a) human lives were involved in the decisions made from the analytical results, and (b) the statistical techniques, within their recognized limitations, can serve exceedingly well as an unbiased tool in the evaluation of potential procedure precision, individual chemists' accuracy, overall laboratory analytical shortcomings, and pin-point possible combinations of deficiencies in methodology that might otherwise escape rapid detection. The results of such investigations are described later in this paper, but the quantitative implications are evident from figure II.

19. The monograph mentioned previously covered three distinct areas of the technical and scientific literature as related to the chemistry of occupational health, namely: (a) theoretical and practical aspects of the required instrumentation, with emphasis on polarography and spectrophotometry; (b) supporting information such as: bibliography and relevant techniques for the development of an appropriate cross-indexed catalog system; forms for tabulation of data; modern, applicable statistical analysis methods, including control charts and rejection of data criteria; safety in the laboratory; and, (c) detailed analytical procedures.

20. The latter were well established and from the scientific literature (or based on original publications) translated into Spanish. After extensive use in the Peruvian laboratory, these "recommended methods" were mimeographed and distributed to former trainees as well as to collaborating laboratories in the United States and abroad. All were written in a format which included the following categories: a code number—for the interlaboratory identification of standard curves, stock solutions, and related evaluation samples; title, revision date(s), references, theory of method, apparatus needed with illustrative drawing showing catalog numbers for positive identification of components; reagents (and special preparation technique if advisable), detailed procedure—both for initial handling of sample and later steps; sampling method suggested, and precautions or relevant notes.

21. Based on the experience in Peru, it may be concluded that the development of appropriate technical literature, in the native language of the potential trainee, is one of the factors that can contribute to relatively rapid progress in establishing a cadre of scientific personnel. Accessibility to adequate instrumentation, coupled with the fairly long term availability of a bilingual advisor are other crucial facets of the technical assistance ecology. The value of this combination

of factors was also amply demonstrated in the training of industrial hygiene chemists for the various other Latin American Republics.

22. Success of the training operation also hinges, obviously, on the caliber of the candidates one can attract into the discipline. The initial phase of the activity is the most hazardous period since there may be strong hesitancy to embark on a possible career that is not established professionally and therefore, appears to have no immediately visible, widespread employment potential. Such a situation is probably unique to the less-developed countries but may also arise in the emerging nations—if the occurrence in Peru may be projected. In the Latin American countries during 1948, it proved difficult to recruit engineers for training in industrial hygiene. Conversely, the supply of chemists at that time exceeded the demand and consequently, an unusually good source of intelligent personnel was available for development. This fortuitous situation greatly facilitated our task of developing this Peruvian corps of specialists in the chemistry of industrial hygiene.

23. In respect to the other Latin American Republics, a somewhat analogous pattern existed but due to differential rates of economic growth and other factors the degree of personnel turnover varied considerably from country to country. For example, in Colombia (and later in Brazil, Mexico) industry could offer much higher salaries than the government service—and therefore, trained personnel in all categories migrated away from the program. However, in Peru a majority of the original trainees in chemistry (and other phases) are still employed by the Institute of Occupational Health. This may be attributed, we believe, to several factors. Among these are relatively good salaries, modern instrumentation, the possibility of doing some research, and perhaps the presence of an advisor who is interested in stimulating original thinking. Nevertheless every effort has been made to promote interest in the chemical phase of industrial hygiene.

24. A successful technique, for attracting qualified personnel into the latter discipline, involved a combination of communication media. Among these were the presentation of papers at local or international congresses on chemistry (4)—with the collaboration of trainees as co-authors or otherwise, participation in national society meetings or symposiums (5), presentations at occupational health seminars (6), delivery of lectures at universities and meetings of other scientific disciplines (7), and press releases as the occasion presented itself.

25. The last approach was feasible in one instance in Peru, when several deaths resulted from carbon monoxide poisoning on a trans-Andean bus. A short article in the local press by the acting director of the Department of Industrial Hygiene (explaining precautionary measures which should and could be taken to avoid such difficulties), resulted in several contacts. Among these was a well qualified engineer who later was hired and is still employed by the organization. Similar measures were utilized in other Latin American countries in conjunction with the regional consultation and training activities—and served as stimuli to the procurement of personnel.

Expansion of Services in Latin America

26. Beginning in 1950, interest in industrial hygiene mushroomed in a spec-

tacular manner in various Latin countries, including Bolivia, Brazil, Chile, Colombia, Mexico, and Venezuela. This trend was related to the promotional activities of the Institute of Inter-American Affairs, coupled with the awakening of these republics to the fact that so-called "cheap" labor was indeed the most expensive type of labor.

27. Far sighted Latin leaders, perhaps under some social pressures, have enacted advanced legislation related to socio-economic problems of their countries. "These laws, as good as they may seem, can actually be a great burden if there are no effective programs of prevention to reduce the compensation which the laws provide. Also, laws can never compensate for health, or life, or loss of dignity when the worker is no longer a bread winner." (8) However, the time between the promulgation of the idealized theory, and the practical implementation of the respective social innovation can often be quite appreciable. The availability of a cadre of highly trained, specialized personnel (necessarily drawn from various disciplines—as is the case in occupational health), can reduce the time substantially.

28. Regardless of the type of personnel required, the complicating factor throughout Latin America was the language barrier, since very few people at that time had an adequate command of English. In essence, therefore, this was repetition of one problem encountered in Peru—and in view of the accomplishments mentioned above, the logical conclusion was to utilize the Peruvian laboratory as a regional training center for chemists. Such an approach also fitted nicely into the distribution by background and experience of the other five American consultants to the various Latin industrial hygiene programs.

29. Since an engineer-advisor was essential in each program, but one chemist could readily service all the programs from one central location, only the advisor to the Peruvian program was employed as a consultant in the chemical phase. Consequently, while several of the latter had backgrounds in industrial hygiene chemistry, each was able to devote full time to the engineering phase of the respective programs. The principal objectives being to set up the programs and give industrial hygiene in-service training to the engineers.

30. During the period of 1950–60, 28 Latin Americans were trained in the micro-techniques of industrial hygiene, or more correctly called occupational health chemistry. This was effected in Lima under the guidance of the advisor in close collaboration with the Peruvian Chief Chemist, and counterparts. Concurrently with the regional training program, consultation visits were made by the senior author to various countries. A breakdown of activities is given in table I.

31. The major objectives of the visits were to design laboratories, solve special problems, demonstrate new techniques, verify the calibration of the instrumentation, but especially to evaluate, by modern statistical procedures, the reliability of the former trainees' analytical techniques and results—since the latter information was critical to the discovery of occupational hazards and/or the diagnoses of health impairment by toxic constituents in the workers' environment. In view of the obvious importance of such an activity, the means utilized are discussed in greater details in the following section.

Table 1. *Description of regional training and consultation activities in Latin America*

Country	Trainees		Consultation visits, dates (and number in year)	Total
	Active	Total		
Bolivia	0	2	1949, 1953(2), 1955(2), 1957, 1960	7
Brazil	*3	4	1952, 1953, 1954, 1955, 1957, 1960	6
Colombia	1	3	1953, 1954, 1955, 1958(2), 1960	6
Chile	1	2	1953, 1954, 1956, 1958, 1960	5
Venezuela	0	1	1958, 1960	2
Mexico	0	2	1955	1
Uruguay	1	1		
(U.S.A.)***	1	1		
Peru	**10	12	Headquarters, 1948–60	
Grand total	17	28		27

*Two individuals are now working as engineers.

**One chemist employed in the United States, another in Venezuela, and the third is now an engineer.

***Short-term in-service training in chemical techniques for ICA engineer.

Inter-laboratory Evaluation Program

32. "Since it is impossible to submit a given sample to an absolutely identical series of operations in replicate analyses", as mentioned by Landry (9), "the alternate goal is to eliminate assignable causes of error such as inadequate control of certain variables, poorly calibrated instruments, or possibly unrecognized carelessness on the part of the chemist—and thus assure that the remaining sources of variation in the data are of a random nature."

33. "In addition, when a new method is being used in a related group of laboratories or recently indoctrinated scientific personnel are initiating their labor in a given discipline, it is of considerable value to the scientists involved, as well as to the directors of the corresponding programs, to have a yardstick to measure the reproducibility and accuracy of the analytical results reported."

34. The use of statistics permits the attainment of the latter objectives but the ultimate goal is to utilize the feasibility of basing conclusions on data obtained in a planned analytical program. Thus, any potential variation in the results (due to causes beyond the control of the chemist) fall, with a preselected probability, within certain established limits.

35. As cited in a previous paper (9), this philosophy of analytical control was implemented in the Latin American sphere of occupational health activities. The results obtained are reiterated in this presentation as documentary evidence. Thus, it should be fairly evident that the recommendations made in the paper just mentioned are also readily applicable to other disciplines being introduced into less developed or emerging nations.

36. Based on the analytical workload of six laboratories (including the Peruvian training center), and as illustrated

TABLE 2. *Results obtained by the various Latin American occupational health laboratories on three synthetic mineral mixtures*

			Sample			
Lab.		*1*	2	3	*Total*	*Lab. ave.*
			Quartz in mineral, %			
A		20.09	52.46	76.73		
		19.89	52.35	76.31		
		20.43	51.90	76.52		
	Total	60.41	156.71	229.56	446.68	
	ave.	20.136	52.236	76.520		49.631
B		18.41	51.03	75.08		
		18.07	50.81	73.61		
		18.35	51.38	74.65		
	Total	54.83	153.22	223.34	431.39	
	ave.	18.276	51.073	74.446		47.932
C		22.08	53.13	79.33		
		21.55	54.71	79.00		
		22.62	54.55	80.93		
	Total	66.25	162.39	239.26	467.90	
	ave.	22.083	54.130	79.753		51.989
D		18.58	51.89	77.70		
		18.70	52.57	78.19		
		18.10	52.07	78.11		
	Total	55.38	156.53	234.00	445.91	
	ave.	18.460	52.176	78.000		49.545
E		18.59	51.72	77.57		
		18.57	51.73	76.93		
		18.62	51.77	76.93		
	Total	55.78	155.22	231.43	442.43	
	ave.	18.593	51.740	77.143		49.159
F		17.47	46.66	70.72		
		17.42	47.18	71.40		
		17.03	46.89	71.07		
	Total	51.92	140.73	213.19	405.84	
	ave.	17.306	46.910	71.063		45.093
G		18.79	52.08	76.93		
		18.83	51.81	76.93		
		18.75	52.06	76.97		
	Total	56.37	155.95	230.83	443.15	
	ave.	18.790	51.983	76.943		49.239

TABLE 2. *Results obtained by the various Latin American occupational health laboratories on three synthetic mineral mixtures*—continued

Lab.		Sample 1	 2	 3	Total	Lab. ave.
		Quartz in mineral, %				
H		18.34	51.23	76.11		
		18.35	51.38	76.54		
		18.63	51.31	76.09		
	Total	55.32	153.92	228.74	437.98	
	ave.	18.440	51.306	76.246		48.664
			Excluding laboratory F			
Grand total		404.34	1093.94	1617.16	3115.44	
Grand average		19.254	52.093	77.008		49.451

in figure II, interlaboratory evaluations of accuracy were effected for only two toxic constituents, lead and quartz.

37. Insofar as the quartz method was concerned, a synthetic mixture composed of orthoclase, oligoclase, and quartz of known purity was ground to 200 mesh and mixed thoroughly. Three concentration levels were prepared and sufficient quantities, quartered individually, were distributed to eight laboratories for analyses in triplicate by the method of Talvitie (10). Only original data, tabulated directly on special forms provided to the collaborating laboratories, and given in table 2, was submitted to the statistical analyses procedure outlined by McArthur et al. (11).

38. No wild results were found but sample averages differed more between laboratories than would normally be expected from replicate measurements—possibly due to intentional sequential analyses. Variance tests indicated that one laboratory was out of control, statistically speaking; whereas, another's data had to be discarded because the reproducibility was too good, i.e., it demonstrated an unusually low variance and therefore could not be compared to the data from the other collaborating laboratories. The difficulty in the first case was traced to an unsuspected and unwarranted modification in the technique instituted by the chemist at his own discretion. Consequently, positive benefits of the statistical evaluation are self-evident because a laboratory having difficulties with the procedure can be localized in an unbiased manner.

39. The analysis of variance data shown in table 3 indicated that there was an interaction effect. This suggests the need for additional work to ascertain why there is an interplay of experimental factors. Nevertheless, based on the refined data, a working approximation of the repeatability and reproducibility that may be expected from this procedure is available from a partition of variance components. The respective values were ± 1.74 percent and ± 0.61 percent. Consequently, since quartz contents of etiological significance are tabulated at 5 percent and greater for 200 mesh material, it is evident that Talvitie's method permits the evaluation of this toxic constituent with adequate precision to ascertain the potential hazard involved, within the limitations inherent to the

TABLE 3. *Analysis of variance in quartz determination (five laboratories, excluding C, F and G)*

Source	Sum of squares	Degrees of freedom	Mean square	F
Between samples	25127.51	2	12563.76	....
Between laboratories, V_L	17.76	4	4.44	*2.67
Interaction, V_I	13.30	8	1.66	**17.47
Replicates, V_O	2.85	30	0.095	....
Total	25161.42	44	....	....

*Not highly significant, $F_{.99}$ (4, 8)=7.01
**Highly significant, $F_{.99}$ (8, 30)=3.17

TABLE 4. *Results obtained by five Latin American occupational health laboratories in the determination of lead in blood*

		Micrograms Found by laboratory						
Sample		*A*	*B*	*C*	*E*	*G*	*Ave***	*Added*
1		5.9	4.4	3.0	4.0	4.1		
		5.9	5.5	3.8	3.8	4.1		
		5.5	3.5	4.0	3.7	4.1		
	ave.	5.77	4.47	3.60	3.83	4.10	3.84	4.0
2		9.3	7.7	7.9	7.5	7.9		
		8.8	8.4	7.4	8.1	8.3		
		9.2	*(3.8)	7.7	7.9	8.5		
	ave.	9.10	8.05	7.67	7.83	8.23	7.91	8.0
3		11.1	11.4	12.3	11.8	11.9		
		12.9	11.7	12.3	12.4	12.6		
		12.9	11.0	12.3	12.3	12.3		
	ave.	12.30	11.37	12.30	12.17	12.27	12.25	12.0
4		15.7	16.2	16.2	16.1	16.4		
		17.0	17.9	16.0	15.7	16.2		
		16.2	18.0	17.1	15.9	16.3		
	ave.	16.30	17.37	16.43	15.90	16.30	16.21	16.0
5		21.2	22.2	20.5	20.3	20.7		
		21.4	22.7	18.4	19.8	20.4		
		20.2	21.7	20.0	19.8	21.4		
	ave.	20.93	22.20	19.63	19.97	20.83	20.14	20.0

*This value was discarded and replaced by the average.
**Excluding data from laboratories A and B.

usual sampling technique utilized (so called settled dust or rafter samples).

40. A series of blood samples, prepared in random order from citrated whole blood by the addition of known volumes of a standard lead solution (prepared from a common stock solution), were analyzed in random order in five Latin countries by the method of Bambach and Burkey (12). The resulting data are given in table 4, and the joint confidence ellipse parameters for the individual laboratories were calculated according to the technique of Mandel and Linning (13).

41. Figure III which was constructed from the latter data may be interpreted to mean that three of the five laboratories tested had "blanks" and standard curve "slopes" which were compatible. The respective data could, therefore, be "pooled" to construct a least-squares standard curve to serve as a reference model for the collaborating laboratories. Conversely, any data that fell outside the ellipse indicated the need for further investigations to ascertain the relevant reasons. Other statistical conclusions can also be reached from the complete data of the study.

Observations on the Present Scope of the Operation

42. Since July 1960, when consultation in the chemistry of occupational health was phased out, the individual laboratories have been operating independently and without centralized direct supervision. This was the ultimate objective but such an approach suffers from a basic weakness. This is essentially related to the termination of inter-laboratory evaluation of accuracy and precision. An appropriate mechanism (possibly within an organization such as the UN, AID, or OAS) was suggested but not implemented as yet. It is to be hoped that the appropriate action will be initiated in the near future. The timeliness is evident from the inter-laboratory evaluation data reported and the turnover in personnel as related to securing of meaningful data that is a prerequisite to reaching conclusions and decisions involving human lives.

43. Investigations concerning the development or modification of analytical procedures have continued, at least in the Peruvian laboratory. However, a major shortcoming is the lack of publication in the American and foreign scientific literature. Admittedly, the Institute of Occupational Health in Lima publishes its own tri-monthly "house organ" (with articles on new methods, surveys, etc.) but the distribution is necessarily limited in nature as compared to full-fledged scientific journals. This is an area that requires deserved attention because the staff of the Institute is capable of doing some original thinking and these ideas should be disseminated.

44. A commendable facet of the present operation is the inter-country collaborative effort between the emerging nations or less developed countries. Thus, the Peruvian laboratory has continued to train chemists from other countries, notably Bolivia and Colombia, but this mechanism is also losing some of its impetus. The collaboration of the multilateral agencies mentioned above could greatly augment the scope of this operation.

Recommendations for the Transfer of Experience to Less Developed or Emerging Nations:

45. The following steps are suggested as potential criteria for applying the

latest advances in science and technology in the less developed areas of the world.

(a) Any candidate for training in a given specialty should be selected by competitive examination and given preliminary in-service observation to ascertain scientific, administrative and/or leadership qualities. Unsuitable personnel should be discharged at this stage of the operation.

(b) Trainees that demonstrate superior talent should eventually be given an opportunity for advanced study abroad, i.e., in the United States, Europe, or in a neighboring third country—but only after having been continually employed by the organization for at least 15–24 months.

(c) The consultant to the specific program should be fluent in the language of the country, tend to be an extrovert with a diplomatic approach to the solution of the major problems to be encountered, and keep abreast of the latest developments in his specialty. This would include continuous, periodic publication in the respective literature and attendance at international meetings (accompanied insofar as possible by his understudy in the host country) related to his major field of interest.

(d) Once a cadre of specialists has been developed, the formation of a professional scientific society should be undertaken. The latter should be dedicated to promoting the expansion and development of the respective discipline. Such action tends to create a cohesive force and draw the young professionals together for more concentrated creative thinking and productivity.

(e) The establishment of a regional center, to provide up-to-date technical backstopping to the components of the new discipline, is strongly recommended. This facility, possibly having expensive equipment for common usage to effect economy, would permit inter-country collaboration between neighboring nations that are in a similar state of development. Financing and maintenance could well be a noble project for a multilateral agency.

(f) As soon as the analytical volume warrants the effort, a system of inter-country evaluation of accuracy and precision of the laboratory results obtained should be instituted. Such activity instills confidence in the recently trained personnel and gives the director of the operation an unbiased tool to ascertain progress as well as help guarantee the validity of the data reported. This is especially relevant where human lives may hang in the balance insofar as action to be taken on the basis of the analysis effected.

(g) The continual development of new methods, and publication in international scientific journals are also important facets of the discipline's evolution with optimal efficiency and scope.

46. In conclusion, the results outlined in this paper perhaps constitute a tangible measurement of the contribution made by the cooperative efforts of native and foreign specialists aided by United States technicians—and the modus operandi, as outlined in the recommendations, is still applicable today in other less-developed or emerging nations.

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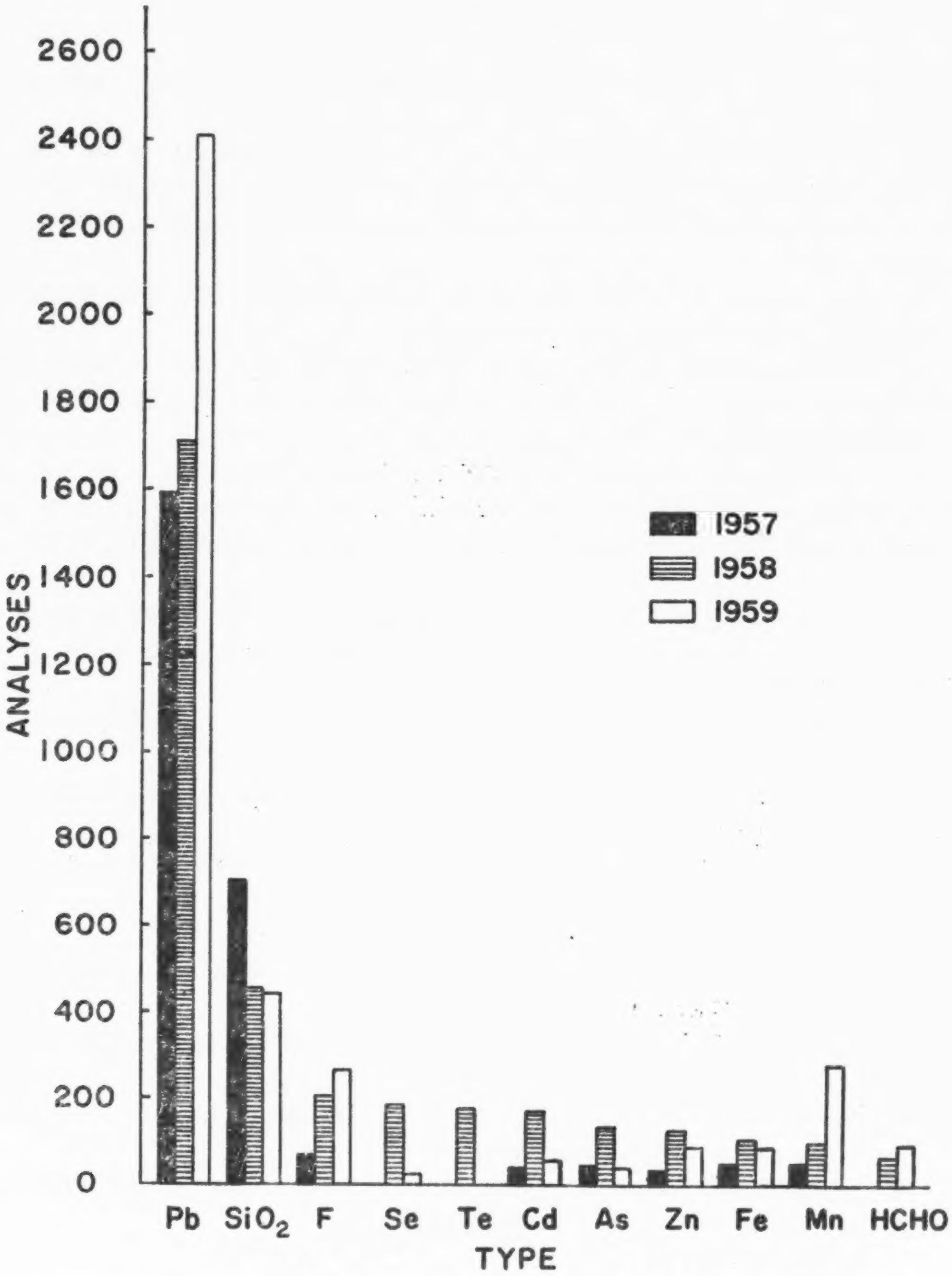

FIGURE 1. Types of analyses effected in various Latin American countries by Occupational Health chemists.

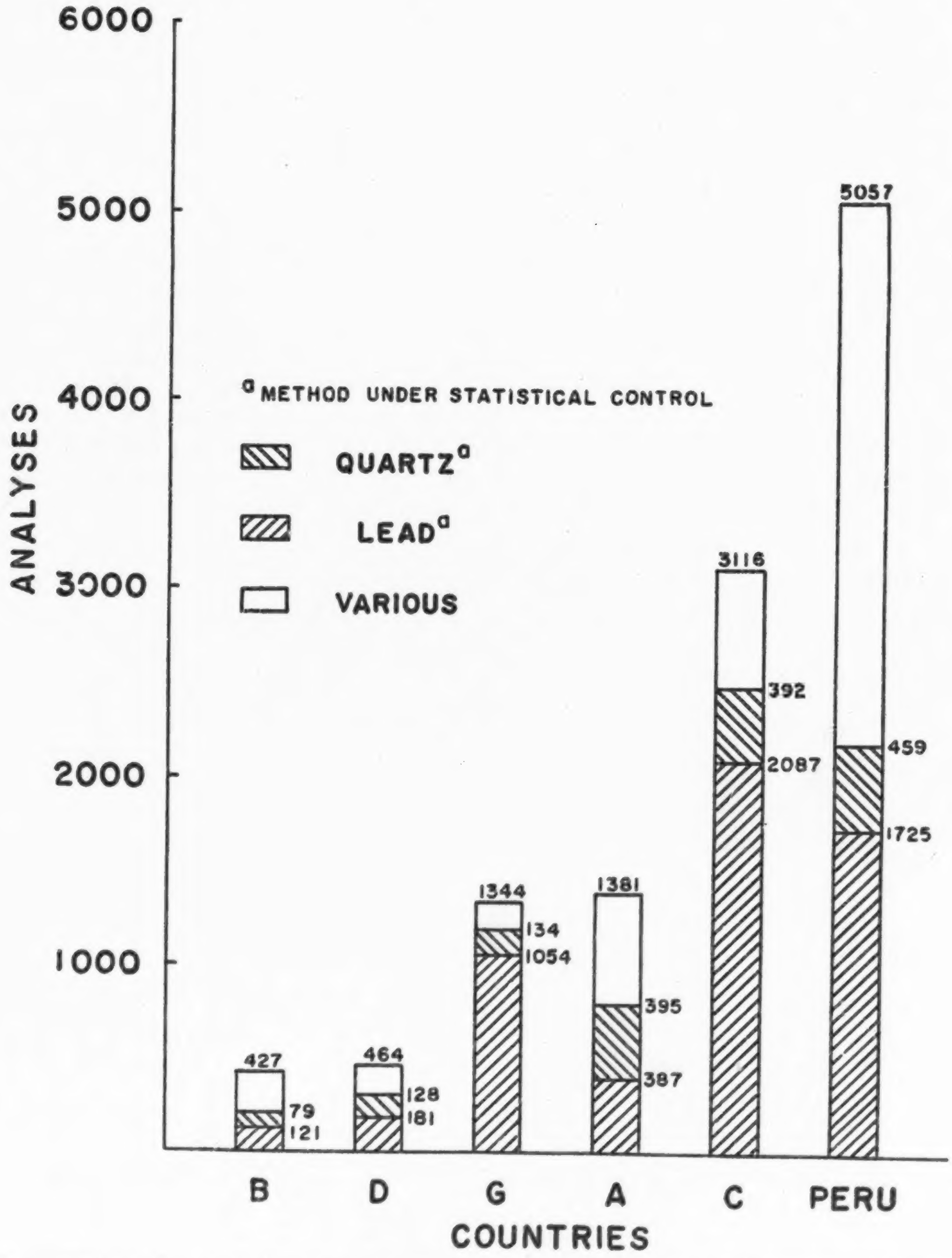

FIGURE II. Analyses carried out during 1957–59 in the Occupational Health laboratories of Bolivia, Brazil, Chile, Colombia, Peru, Uruguay, and Venezuela.

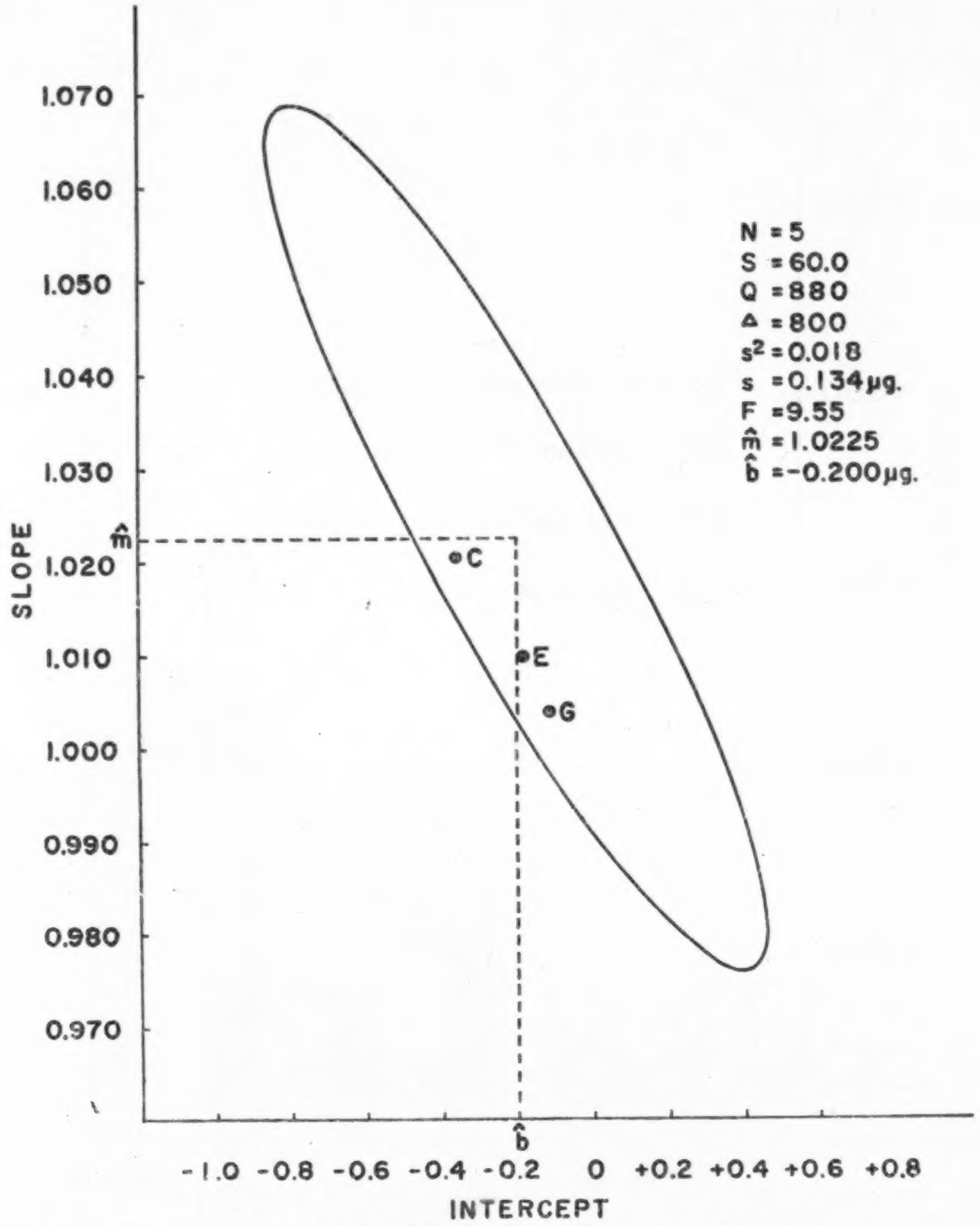

FIGURE III. Joint confidence ellipse for the determination of lead in blood (4.0 to 20 micrograms per 10-gram aliquot).

Women in the Labor Force*

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1. The position of women in a society has long been considered an index to its degree of civilization. For the most part this concept relates to the legal and social status of women and their acceptance by men as partners in life rather than merely as chattels, servants or bearers of children. Historically, the ancient civilizations where women were held in esteem as persons were usually the societies which contributed greatly to advances in knowledge, the arts, and social and political organization. In Babylon under Hammurabi, in Egypt under the Pharaohs, in Rome during the height of the Empire, women enjoyed extensive property rights, personal freedom and education, rights which were generally lost to them during the Middle Ages. Many of these rights were re-won in modern times only with the emergence of industrialized societies.

2. It is a matter of pride to Americans that the new spirit of freedom and independence generated by the settlement of North America also stimulated those movements in the 19th century which have produced so many personal, political and economic gains for women in the United States. If one can apply the term "export" to intangibles, it is certainly clear that these ideas of woman's rightful place in modern society have constituted an important part of our foreign trade to many parts of the world. Today the women of the Far East and of Africa are throwing their intelligence and energies into the improvement of women's position and thereby the well-being of all in their own newly developing countries.

3. It would be a difficult matter to prove that industrialization per se has "caused" the change in women's status in the world. Nevertheless it is clear that her political rights, her social status and her freedom to conduct herself as an independent and responsible person have developed since machines began in an important way to take the place of hands in the production of goods, and since agriculture fell heir to technology in the production of food. To these revolutionary developments in human living and economic enrichment women have made and are continuing to make great contributions. Indeed it would be hard to imagine how an industrial society, wherever located in the world, could function without the participation of women as employees. Their special aptitudes for certain kinds of work, the sheer need for their numbers, as well as other potent

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*UN conference paper.

factors, make them indispensable in an expanding modern economy.

4. In a paper this brief, it would be impossible either to traverse the history of women's employment or to describe in detail the present participation of women in the labor force throughout the world. The particulars vary substantially. Even among the industralized countries the proportions of women in paid employment outside the home differ greatly. In the United States, for example, one-third of our labor force is women, in the USSR it is over half, whereas in the Netherlands it is only 15 percent. Occupational distributions also vary. Although, for example, women are about three-fourths of all teachers in elementary and secondary schools in both the United States and USSR, three-fourths of all Russian doctors are women, compared with 6 percent in the United States. On the other hand, women are close to three-fifths of all agricultural workers in Russia compared with only one-fifth in the United States. In many of the newly evolving countries, too, a substantial body of agricultural work continues to be done by women, as has been traditional throughout recorded history. Indeed, archeologists generally give credit to women for "civilizing" wild grains, thereby giving birth to domestic agriculture itself, and consequently to the establishment of settled communities. Development of human society has come a long way since then, but it is well to remember that it was the acuity of women and their labor in the fields that brought man his first bread.

5. The most useful perspective on the subject of women's work in the U.S. including its social and cultural as well as its economic implications, can be achieved by tracing the progress of women to their present strategic position in the country's labor force. Perhaps a not-too-well recognized fact in our national history is that, with the first settlements on the North American continent, women shouldered the burdens of conquering a wilderness equally with the men. There were no sources of supply for food or clothing or shelter, other than in the new land and in the hands and sinews of the settlers themselves. The shops and farms of Europe were 3,000 dangerous miles away, across a forbidding sea.

6. In order to eat, corn and grain had to be planted and harvested, wild meat and fish preserved against the winter; material for clothing had to be woven from flax and wool, and garments fashioned; children had to be raised and schooled. These tasks fell largely to the women while the men felled trees, built houses, hunted game, made the laws, and protected the meager settlements. Indeed, women often took up the rifle to strengthen the defense. There was insufficient time and insufficient labor to permit women to be kept out of the basic tasks of the endeavor to build a new nation. And out of this cooperative economic effort women developed a sense of their own value as workers and partners which helped them later to win recognition of their entitlement to equal status with men as individuals and citizens.

The World of Women's Work in the United States

7. As early as the 1830's the unusual quality of women in the United States was noted by that sensitive observer of social customs, the Frenchman Alexis de Tocqueville. In his book *Democracy in America* he wrote, "I do not hesitate to

avow that—I have nowhere seen women occupying a loftier position; and if I were asked—to what the singular prosperity and growing strength of that people ought mainly to be attributed; I should reply—to the superiority of their women." By the time of de Tocqueville's observation, the textile industry had been established for some years in New England and already was drawing upon the young women in the rural areas for its labor supply. The heart of the matter, and the opening door to a new world of opportunity for women, was the fact that male labor was in short supply. Vast untouched lands lay to the West; the men went out to them; New England's unattached daughters went into the mills at home. This illustrates how in our early history women responded to industry's need for workers. Industrial leaders of the time extolled the merits of female employment. To it they attributed an improvement in morals, a reduction in idleness and dependency, and greater financial security for women; in short, a good thing all around.

8. Later, when women demanded the right to vote, they were often branded, as irresponsible and immoral for this ambition, but the long record of their economic contribution to the country's development as paid workers was among the most effective arguments for their political enfranchisement.

9. Today there are 24 million women in the United States labor force, constituting one-third of the total, and 36 percent of all women of working age (14 years and over). The female work force is older than it used to be. Half of our working women are more than 40 years of age; almost two-fifths are 45 or older. Over half our women workers are married and living with their husbands; and of all married women in the population, one-third are working in paid employment. Of course, much higher proportions of single women work—over 75 percent.

10. Women are employed in every major occupational group and in almost every one of the hundreds of specific occupations in the economy. Indeed there are few jobs left that are exclusively "men's jobs." In some, of course, only a few women are to be found. These are the extremely heavy or hazardous ones—like stevedoring, or astronauting. Most women who work are employees, but several hundred thousand run businesses of their own. More and more are entering professional and technical employment, of which teaching and nursing claim the highest proportions, but even greater numbers earn their living as clerical and office workers, operatives in factories and as service workers outside of private households.

11. Since 1940, the proportion of women among all employed workers has increased from one-fourth to one-third. Present projections indicate that women will constitute almost half the net increase in the total United States labor force at the end of the present decade. Their current participation in various occupational groups varies, of course, but over the past twenty years they have gained a far greater share than men of the increased employment in all the fastest growing occupations except the professional group. Their place has risen from 11 to almost 15 percent of all managerial jobs; from 54 to 68 percent of all clerical; from 26 to 36 percent of all sales; and from 38 to 52 percent of all service jobs outside of private households. Only among professional workers and factory operatives have their pro-

portions remained unchanged since 1940—around two-fifths of all professionals and one-fourth of the factory group.

12. Although women need to make much more progress in professional and technical work, the changes in their occupational attachments indicate that they are succeeding in moving out of the more menial and poorly paid work into occupations requiring more skill and education, and offering them more dignity. They are thus demonstrating their ability to advance with our times, wherein jobs requiring higher skills and more education are expanding faster than others.

Legislation Governing Women's Employment

13. The path to today's achievements by women in the working world in the United States has not been an easy one. It is no exaggeration to say that for many, many years their labor was exploited—their hours of work, in factories especially, were long and often extended far into the night; their pay was very low compared with that of men; there was little concern for their health or their safety in the work surroundings. The abuses of the unregulated industrial homework system, wherein whole families were employed, including women and young children, were so great as to constitute a disgrace to the Nation's rapidly expanding nondurable goods industries. Even in the one professional occupation in which women were more fully accepted, the teaching of young children, their personal lives were constantly subject to the scrutiny of local school boards.

14. Eventually, the Nation's social conscience responded to the challenge of widespread substandard working conditions. Today, after a century of development, each of the 50 States, the District of Columbia and Puerto Rico have laws relating to the employment of women. In 1962 almost all of our States have established standards of maximum daily or weekly hours for women, and a number of them have laws establishing a day of rest, meal periods and regulation of nightwork. The exact provisions vary and indeed there is some disagreement as to whether some, particularly nightwork provisions, may not be too restrictive, possibly an anachronism in the modern world. But our population generally supports legislation on hours of work that will protect health, insure the opportunity to carry out family obligations, and provide sufficient leisure. Many of these standards are now being observed generally for all workers, irrespective of sex.

15. The second step forward came in the area of minimum wages. In the late 19th century and in the first decade of the 20th, wages paid to women were generally so pitifully low as to fail to provide them a living wage. Absence of wage payment laws often cheated workers, men as well as women, even of the pittance they had earned.

16. Arguments for a decent minimum wage for all workers fell on barren soil, but the arguments in behalf of a minimum wage for women, "to protect their health and morals" eventually won response. In 1912, the State of Massachusetts passed the first minimum wage law. In 1962, 35 jurisdictions provide for the establishment of minimum wages for women, covering a variety of occupations, and using various kinds of procedures. In some States men are covered as well. Of course, the national Fair Labor Standards Act applies equally to both sexes. Its passage, in 1938, reflected the yeoman service performed by State legislation in

the prior 25 years in educating the public and employers to the value of a floor for wages below which no worker could be hired.

17. The great unfinished business of today's working women in the United States is to get overall legislation in the field of equal pay. True, 22 States do have such legislation, establishing the principle of payment of "rate for the job," irrespective of sex. World War II stimulated legislation of this kind because of the devoted work of women in our war production industries and in the myriad of services previously performed by men. In the autumn of 1962 national legislation providing for equitable wage treatment for women workers made more headway in the Congress than ever before. Meanwhile, over the past two decades, trade unions and women's organizations have kept up an educational campaign on this front. As a result, many employers have voluntarily recognized the fundamental justice of the principle of equal pay and have moved to discard their earlier inequitable pay practices.

18. American legislative history in these areas of standards for women workers carries a lesson for the newly emerging nations. Their womanpower will be needed to hasten their development, but their womanpower cannot attain its greatest industrial productivity unless reasonable standards for working conditions prevail from the very beginning. Our history of struggle, and that of other, great industrial nations, should be convincing. These principles are recognized, too, in the resolutions and recommendations of the ILO. To the women of the new countries of Asia and Africa, we would say, "Don't consent to repeat our struggles. Start, as nearly as you can, from the level we have reached." It is not suggested that we in the United States have reached an ideal condition, and that we have nothing more to do, but at least we have come some distance along the way. Trade unions, employers, civic groups all recognize that decent wages and working conditions and nondiscriminatory practices toward women are the sine qua non of a healthy and forward marching economy.

The Pattern of Working Life of Women in the United States

19. The life pattern of women in the U.S. has been substantially altered by the demand for their work as paid employees and their response to that demand. The modern pattern of women's employment reflects not only a radical change in the attitudes of our culture in general over the past century and a quarter, but a change in the attitudes of women themselves to work outside the home and to their total role in our society.

20. Perhaps the best way to vignette this pattern, which has been developing over the past decade or so, is to start with the young girl just finishing school (in the United States most girls complete at least 4 years of high school). Most unmarried girls will then go to work, at age 17 or 18, unless they enter college. Within 3 or 4 years, most of these girls will marry. Some of them will stop working for pay in order to get a new home organized, but a majority will continue to work. By keeping her job a young wife may help put her husband through school, may make it possible for them to buy a home, a new automobile or the labor-saving equipment that modern industry produces in such abundance. But there is another, more basic motive underlying the decision of many

women, especially those who are highly educated and career-minded, to work after marriage. It is a desire to have a rounded, complete life in which they can achieve a sense of participation in and contribution to every phase of our national life.

21. When the first baby arrives, however, the vast majority of young mothers give up their jobs and remain out of the labor market until their youngest child is old enough to go to school. It is true that as many as one in seven women with preschool-age children do continue to work, many because of economic necessity, but the general pattern is that the age group 25–34 supplies the lowest proportion of women workers. Here, again, the woman has a choice. Even though there is no great economic need, if the mother feels she can make a greater contribution by providing capable care for her children and continuing work, she may well do so.

22. In the majority of cases the trek of mothers back to paid employment begins when the youngest child no longer needs constant care. This usually happens when the women are approaching their middle thirties, after they have been non-wage earners for about 8 to 10 years. Once back, the tendency is for them to remain in the labor force, perhaps not continuously, but certainly for a substantial proportion of their years to age 65. By 1970, nearly half of all women between 35 and 65 probably will be either working or looking for work. Unless things change radically and unexpectedly in the years ahead, the highest labor force participation rate will be among women aged 45 to 54.

23. These comments have concentrated on the life pattern of married women because they will be in the vast majority. But for the small proportion of women who remain single, the length of working life will be little different from that of men. Since most single women must support themselves, and often parents or other relatives, they must continue to hold a job. In summary, the "work-life expectancy," as it is often referred to, looks like this for women: For single women, 40 years at work; for childless married women, 31 years, and for married women with children who do decide to reenter the work force, a discontinuous total of 27 years, or about 4 years before marriage and 23 years after. For women who are widowed, divorced, or separated from their husbands (22 percent of the female labor force in 1960) the pattern of working life, once they reenter paid employment, becomes more nearly like that of the single woman.

24. Within this general overall pattern there is great variety, and one should not assume that this will be the life story of every girl in the United States. Some, a relatively small proportion, marry and go directly into homemaking without any period of paid employment, and never do actually get into the labor force at any time in their lives. Another group, which seems to be getting smaller all the time, are the women who leave their jobs when they marry or have their first child, and never return to paid employment afterward. Lest you think these situations mean a cloistered, utterly domestic life, let me hasten to add that many of these women make an important contribution outside their homes through volunteer work in civic, political, educational or artistic fields, without which community life in the United States would indeed be poorer. But this type of work, because unpaid, does not qualify these women to be counted as members of the labor

force. Many women in paid employment also participate in these volunteer groups, but their available time for such activities is obviously more limited.

25. At the opposite end of the scale are the married women who follow what has been called a "double track" arrangement of both homemaking and employment, wherein the continuity of work is interrupted briefly for the birth of children, after which the woman returns to work. This pattern is characteristic of many women who have had specialized professional training, such as doctors or government officials, and at the opposite end of the economic spectrum, the women in low income families who must continue to work to assure the essentials of living for their families, even though a husband may also be present.

26. For most of our history in the United States, indeed until well into the present century, the indigenous culture frowned upon the idea of a married woman working outside her home. A young man was considered improvident and undesirable, and a young girl foolish to consider him as a husband, unless he was able to support her and their children without her assistance through outside work. But cultural patterns respond to economic and other changes, such as rapid acceleration in the industrial process and the need to supplement the labor force in time of war. Both these factors, plus the rising educational attainment of women, have broken down what now seem antiquated mores. To have a working wife is no longer a "disgrace" to a man, nor is being a working wife a badge of shame or poverty to a woman.

27. The old myth of marriages "ruined" by wives working outside the home has disappeared; in fact, the statistics on marriage indicate that a young woman's ability to bring home a pay check has actually stimulated marriage and at younger ages. Whereas in 1890, 55 percent of the women and 52 percent of the men were married (excluding widowed or divorced), in 1960, 66 percent of the men and 70 percent of the women were married and living with spouse. In 1890 the median age at first marriage was 22.0 years for women and 26.1 years for men; by 1940 this had dropped to 21.5 for women and 24.3 for men, and by 1960 to 20.3 for women and 22.8 for men, a decrease of almost 2 years for women, and 3.3 years for men, most of this change having taken place since 1940. The model age for girls is now even less—a mere 18 years. Our young men are clearly either bolder, or feel more financially secure by virtue of being able to take a wife who can earn. As for our young women, they are less willing to endure long engagements until their prospective husbands can support them and families without supplementary income. Thus the needs of our industrial economy and the gentler bonds of romance have conspired together to stimulate the participation of women in the labor force.

Education and Training of Women

28. The rising level of women's contribution to the United States economy would not be possible, however, had not our educational goals and free public schooling been available to them. Their achievements in the world of work, like those of men, depend to a high degree on the amount and quality of their education.

29. In the last few years it has become a truism among economists and vocational counseling specialists that the great

employment expansion of the future will be in those occupations requiring higher levels of education and skill. Unskilled jobs on the farm and in industry are declining rapidly; more and more semiskilled jobs will yield to automation. The job outlook is brightest for those who have something specific in the way of skill or professional training to offer an employer. Gone is the day when a worker who says he "can do anything" is considered a prize. In our modern economy we know this is not true, and it behooves the seeker for work to be able to do something and, moreover, something that an employer wants done. Recent studies by the United States Department of Labor of the actual work experience of young people demonstrates conclusively that those who discontinue their formal education before completing 4 years of high school (we refer to them as "school dropouts"), have more difficulty getting jobs, get lower-skill jobs, earn less money, and have substantially more unemployment than those who complete but do not go beyond high school. Among girls, for example, 60 percent got office jobs immediately on finishing high school compared with only 11 percent of the girls who have dropped out. Unskilled jobs claimed 55 percent of the dropouts, but only 12 percent of the graduates.

30. Today, education to at least age 16 is required generally throughout the United States. This applies to girls as well as to boys. In 1961 over nine-tenths of all girls (and boys) between 7 and 17 were enrolled in school. The majority of both sexes remain in school until they get a high school diploma. In fact, somewhat higher proportions of girls than boys complete the course. After age 17 enrollment rates drop, but more sharply for girls than for boys, reflecting the fact that higher proportions of men than women go on to college. Nevertheless, about 1½ million women (6 percent of all female school enrollees under age 35) were attending colleges or professional schools in the fall of 1961, compared with about 2½ million boys (9 percent of all male school enrollees under age 35). Roughly another 300,000 girls between the ages of 18 and 24 were enrolled in some type of private trade school or business college, such as art, cosmetology, fashion design and others.

31. The educational attainment of women at college level continues ever upward. For example, women attending college in 1961 were double the number attending in 1950, although the number of girls aged 18 to 21 (the normal age-span for college attendance in the United States) had risen by only 12 percent in that decade. The median number of school years completed by women in the labor force in 1959 was 12.2 years, or something better than high school, compared with 11.5 years for men. For both sexes the educational attainment of the labor force exceeded that of the total adult population by something under one-half year. Though the educational level of the labor force is high, the manpower needs of the future will require increasingly more education and more specialized skills, not only in the United States but in all developing countries, no matter what the present level of their economy.

32. Women in the United States have not achieved their relatively high educational level all at once. A century ago a college education for women was a rarity, and the fight to establish educational facilities equal in quality to those available to men was bitter and long, just as was women's battle to enter the professions. Quite aside from matters of prejudice and

discrimination, one could hardly expect to become a lawyer or a doctor or an architect or a nurse without the necessary training. The importance of access to education as a prerequisite to achievement in work is obvious in theory and is proven by facts. In 1959 the largest percentage of women in professional occupations had a college education; in clerical, managerial and sales occupations, 4 years of high school, and in operative and service occupations, an elementary school education.

33. A fairly recent development has been the introduction by educational institutions in the United States of programs to provide continuing education for women with college training who either interrupted their careers for marriage or who never put the skills and talents they developed as students to use because of early marriage. These women are invited to return to classes to renew skills or to train for new ones. Some of these programs, notably that of Radcliffe College, are particularly concerned with the highly gifted women.

34. To those who want a high level of economic opportunity in the future we in the United States continue to say, and with greater and greater intensity: "Go to school, develop a skill, learn a trade, prepare for a profession. The race will be to those who know and to those who can do."

35. This advice is equally applicable to women in all parts of the world, no matter from what economic base their countries may be forging ahead into an industrialized society. We have attempted to help them realize their goals for economic and social advance. The United States Government has, since the mid-1940's, been opening up its resources for training and observation and study to women from all over the world. It has financed scholarships and training grants to hundreds of women from Afghanistan to Yugoslavia. Many others have come to the United States through grants by private industry, international agencies, educational institutions, civic groups and women's organizations.

36. The U.S. Department of Labor alone has prepared and carried out programs for a thousand women from 75 countries. These women have come from a great variety of professions, backgrounds, and program interests. Among them have been lawyers, doctors, social workers, Directors of Bureaus for Women and Children in Ministries of Labor, teachers, housewives, community and organization of leaders, journalists, radio and television broadcasters and programmers, government officials, trade union leaders, factory and office workers, volunteer social workers, vocational guidance experts, market women. They have had the opportunity to confer with workers here in similar positions, to see new developments in this country in their fields of interest, to learn methods of improving working conditions, of educational and training facilities, of programs of rehabilitation for the blind and other physically handicapped; how to make studies and surveys on which to base action suitable to their countries' needs. They have participated in planning their programs and in suggesting places and persons to see. Their freedom of choice in working out their schedules has been encouraged.

37. We do not for a moment believe that this international exchange is a one-way street. After all, the United States is a changing society too, and we learn through the fresh eyes and minds of others where we are rigid, resistant to recognition of needed change, unaware

of areas where our own past solutions will not be appropriate for different conditions. One of the most heartening results of our visitor programs in the United States and our technical assistance programs abroad have been the stimulation of our own citizens by what they have heard and seen and experienced through contact with other places and other societies. For example, one question that foreign women visitors raise so often with us is, "Why do you not provide for better and more day nurseries, child care centers, household services for working mothers?" Or, in an entirely different sphere: "Your women are so alert, so well-educated, so independent in spirit. Why do you have so few of them in elective or appointive office?" These questions give us pause. We learn from our guests ways in which we can put our own house in better order.

38. The woman worker in the United States intends to move forward from where she is. She does not intend to be satisfied with her achievements in the past. We women still have to win the battle of equal pay in some lines of work. There are still areas of discrimination in job opportunities and in advancement. To assist her in these unfinished tasks the modern woman in the United States does have one precious privilege in abundance—her personal freedom to choose what she will do with her life: whether she will marry or not; whether if married, she will work or not; what occupation she will train for; how she will use the money she earns. Through her liberty to act, she influences to a major degree the cultural and economic changes in our society by cherishing, cultivating, and buttressing one of the most fundamental of her human rights—her right to work.

Occupational Safety in a Newly Developing Industrial Area*

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1. It would be highly unrealistic to assert, or even to imply that a high level of occupational safety can be achieved quickly in a newly developing economy. True, we have the technical know-how to eliminate almost all physical hazards associated with employment. But we also know from long experience that safety is not simply an engineering problem. Human attitudes and economic factors weigh heavily in the final determination of the success or failure of an occupational safety program. Above all, we know that safety isn't something that can be learned in one lesson or ordered into existence for now and forever by those in authority.

2. True occupational safety is a way of life in which workers, management, and government must all participate. It must be rooted in a sincere respect for the dignity, physical well-being, and economic welfare of the individual. It gains strength and viability from an understanding of the unfavorable social and economic effects which accompany its failure. It reaches fruition only through cooperation and teamwork by all segments of the economy.

3. We in the more highly developed industrial countries have been working toward the elimination of occupational injuries for many years. We have made substantial progress, at times verging on the spectacular, but our goals are high, and we still have a long way to go to reach them. I can speak best, of course, on the developments in my own country, and I want to outline to you the significant steps we have taken over the years. An account of our successes and of our frustrations may help to smooth the way for those nations which are just starting their occupational safety programs.

4. One of the most significant characteristics of our approach to occupational safety is that from the very beginning we have tried to bring into the safety movement all segments of our private economy. We feel strongly that this approach has contributed greatly to our successes and that we have progressed much farther than would have been possible under a strictly government-administered program.

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*UN conference paper.

5. As we look back, however, both in our own history and in that of other industrialized countries, it is clear that safety has never been emphasized in the early days of industrialization. In the rush to expand economic activities accidents have been accepted as inevitable, and prodigal waste of human resources has been the rule rather than the exception. Historically, we must face the unpleasant fact that real interest in safety has rarely developed in any economy until after a relatively high level of industrialization had been attained. In the light of our present knowledge of accident prevention it is difficult to understand why this has been true. Certainly it is difficult to understand why it should continue to be true in the newly developing areas. We know full well that we can design safety into any industrial equipment or process; and we know that if workers can be trained for industrial activities, they can be trained to perform these activities safely. If the newly developing countries accept these conclusions and apply them in their early steps toward industrialization, they can avoid many of our mistakes.

6. The safety movement, as we know it today, had its inception in the latter half of the last century. It grew first from a humanitarian concern for the physical suffering and economic plight of the workers who had experienced serious work injuries. Many of these disabled persons were completely dependent upon charity and public support for their meager livelihood. Out of this concern we developed the concept that the economic costs of these disabilities should be borne by the industries which produced them, rather than by the injured persons, their families, and the public. It soon became clear, however, that this could not be achieved satisfactorily through legal actions in which disabled workers sued their employers for damages. This process was too slow, too expensive, and too technical. Recoveries were uncertain and whimsical; and the legal actions took on the aspects of a lottery in which both the disabled worker and the employer gambled for all or nothing. The entire procedure was unsatisfactory, not only to the employer and worker principals, but also to the public.

7. The concept of workmen's compensation evolved directly from this dissatisfaction. The new thought was that the worker should be guaranteed recompense for his economic losses resulting from work injury without being required to prove fault on the part of his employer. The employer, in turn, would be protected from capricious or unreasonable damages by a fixed schedule of benefits. And for practical purposes, the employer's liability for these benefits would be insurable.

8. Laws effectuating these principles were first enacted in Europe, but the concept soon spread to other industrialized areas. The State of Maryland led the way in the United States by enacting a limited workmen's compensation law in 1902. Technical deficiencies, unfortunately, prevented this law from becoming effective. In 1908 the Federal Government introduced workmen's compensation for some of its employees and in 1916 extended the coverage to all federal employees. In 1911 the first effective State law applying to private employment was enacted. Today, every State in the United States has such a law.

9. As we look back over our experience with workmen's compensation, we realize now that the early concepts as to who should be covered by such laws were

much too narrow. The spectacular possibilities of injury arising from contact with the machines used in manufacturing had an undue weight upon the early thinking about work accidents, and many of the laws were written to cover only manufacturing activities. In large measure this was due to the lack of comprehensive statistics to show that work injuries constitute a problem in all industries, not just in manufacturing. Today we have a more precise knowledge of where and how work injuries occur. We know it was a mistake to exclude agriculture and the service trades from workmen's compensation coverage, and we are moving to extend our laws to cover these activities. The newly developing areas might well give consideration to our experience in this respect and possibly avoid repeating our mistake. It probably would be simpler to initiate broad-scale coverage in the beginning than to start with narrow coverage and have to expand later.

10. As we gained experience in the application of workmen's compensation, some of our basic concepts changed. It became evident that the mere provision of immediate medical care and recompense for a portion of the earnings loss of a seriously injured person was not enough. All too often, seriously injured persons were unable to return to regular employment because they lacked the essential skills for any employment other than that for which their injury incapacitated them. These handicapped unemployables were an affront to our concept of human dignity as well as a distinct loss in our pool of manpower. It became clear that the real objective of workmen's compensation should be to insure the return of every possible injured worker to productive employment and economic independence. Our workmen's compensation concepts, therefore, have been extended to include the occupational rehabilitation of every worker whose injury prevents his return to his previous employment. To accomplish this we have to utilize special medical and orthopedic skills to prepare the injured persons for their new activities as well as providing direct occupational training. We have had excellent success in this, although the program has not moved forward as rapidly as we would like. There has been some reluctance among employers to the hiring of handicapped persons, and some hesitancy on the part of the handicapped persons in accepting rehabilitation. These impediments to the program, however, are being overcome through widespread informational campaigns sponsored by the Federal and State Governments and by private organizations. Now it has been amply demonstrated that physically handicapped persons, when properly placed, are good and effective workers, entirely capable of competing directly with their nonhandicapped co-workers. In the light of these findings our "employ the handicapped" programs and our occupational rehabilitation programs include both those who received their disability in industry and those whose disability is not of occupational origin. We are training and finding employment for thousands of such persons each year. Their lives are thereby enriched and made meaningful and the economy is enhanced by their productive abilities.

11. Workmen's compensation, of course, is not the answer to the work-injury problem. At best it is only a palliative after the unfortunate event has occurred. It has, however, an important place in the safety movement, both for its specific purpose of distributing eco-

nomic loss and as a direct stimulant to accident prevention efforts.

12. Accident prevention had its inception long before the workmen's compensation concept emerged. In the early 1800's a few enlightened employers, employee groups, and civic-minded individuals began to urge correction of the working conditions which led to the occurrence of injuries in the United States. These private efforts to stimulate interest in safety ultimately led to accident-prevention legislation. In 1867 the State of Massachusetts adopted the first factory inspection law in the United States, and in 1877 adopted a law requiring employers to guard hazardous machinery. Equally important to the safety movement, Massachusetts also established a Bureau of Labor Statistics to study, among other things, the work-accident problem.

13. In 1885 the State of Alabama adopted an Employer's Liability Law and Massachusetts followed suit in 1887. These forerunners to workmen's compensation did not directly impose accident-prevention obligations upon employers, but by making accidents expensive and legally troublesome, they stimulated action to prevent their occurrence. Other States quickly enacted similar liability and factory inspection laws and by 1900 accident-prevention activities were becoming common throughout the United States. The insurance companies writing insurance for employers under the Employer's Liability Laws were particularly active in urging the firms they insured to eliminate hazardous working conditions. Many of them instituted plant inspection services and provided engineering consultation to help their assureds make their operations safe. Plant managements responded by establishing safety programs for their own operations. Early records credit the first of these in-plant safety programs to the Joliet Works of the Illinois Steel Company which established a safety department in 1892. This was the real beginning of the American occupational safety movement as we know it today.

14. In 1893 the Federal Government began its active participation. In that year the Bureau of Labor Statistics issued the first of its continuing reports relating to work injuries, a study of European workmen's compensation procedures. This was followed by a series of special reports on workmen's compensation problems and on the hazards associated with particular industrial operations. In 1910 a continuing series of annual injury-rate compilations for the iron and steel industry was inaugurated. In 1925 this injury-rate series was expanded to include 24 industries. At present it covers 260 manufacturing and nonmanufacturing industries. These informational services stimulated a great deal of interest in safety, first by demonstrating the magnitude of the work-injury problem, and second, by showing that real reductions in injury occurrence could be obtained when serious efforts were made to prevent accidents.

15. In subsequent years the Federal Government vastly extended its participation in the occupational safety movement. The Bureau of Labor Standards, in the Department of Labor, has the most widespread functions in this field. As a regulatory agency, it issues and enforces safety regulations for the important maritime industries—stevedoring, ship repair, and harbor work. As a service agency, it assists the States in preparing safety codes and regulations; provides training courses and working materials for State

factory inspectors; performs safety research and participates with public and private organizations in developing effective safety standards; and provides technical pamphlets, safety promotional materials, and safety training courses for workers and management personnel. Every two years it conducts, for the President, a national conference to which he invites some 3,000 leaders of safety activities in their own communities to meet with him in a weeklong discussion of occupational safety problems. Within the Federal Government, it acts as coordinator of all safety activities conducted by the various departments and agencies for their own employees. Of particular significance to the newly developing areas, it provides a wide range of technical training in occupational safety for government and industry people from other countries who have expressed an interest in learning the accident prevention methods applied in the United States.

16. The Department of Labor, also, through its Divisions of Wages and Hours and Public Contracts, issues and enforces minimum safety standards in establishments holding Federal contracts; and through its Bureau of Employees' Compensation, provides a workmen's compensation system for workers in the government and the longshore and harbor work industries.

17. The Federal Government also enforces safety rules for the protection of railroad workers through the Interstate Commerce Commission. The Bureau of Mines establishes standards for safety and promotes safety activities in the mining industry, and the Public Health Service conducts research and provides a wide range of consulting services in the field of occupational disease prevention.

18. In the United States, however, the State governments have primary responsibility for the development and enforcement of occupational safety regulations in most industries. Most of the States have some form of regulation, inspection, and enforcement for the more hazardous industries. These procedures vary somewhat from State to State, but through the influence exercised by the various standardization organizations are tending toward uniformity. A number of the States have successfully extended their safety services to include consultation on safe work practices and processes, and to promoting the elimination of physical hazards and unsafe work practices not specifically covered by the regulations.

19. Outside government, a great step forward was taken in 1912 when the Association of Iron and Steel Electrical Engineers sponsored a national meeting of persons interested in discussing the costs, causes, and prevention of accidents. This group met again in 1913 and organized the National Council for Industrial Safety, which in turn became, in 1915, The National Safety Council. Over the years the National Safety Council has expanded its activities to cover all kinds of accident prevention, but it continues to emphasize occupational safety. The Council is privately supported by its membership, which includes the great majority of the large employers in the United States. It contributes to the safety movement by distributing information on accident prevention, taking the lead in the development of safety standards, and providing a national center for the exchange of ideas on all phases of safety. It provides special technical consulting services for its members, but much of its effort to promote interest in safety is directed to the general public.

20. As a supplement to the National Safety Council, local safety councils have been organized in most large cities of the United States. These councils engage in a wide variety of safety campaigns and activities designed to create and maintain general interest in accident prevention. Membership in the councils is open to anyone interested in safety and includes employers, employees, professional people, government people, and representatives of a wide range of civic organizations.

21. Employers' trade associations have been particularly active in the occupational safety movement in the United States. They have consistently assumed the obligation of keeping their members informed of new developments and have provided representation for their industries in the development of safety standards. Many trade associations provide safety engineering consultation for their members and a number conduct safety contests to create and maintain interest in safety throughout their industries.

22. In recent years a number of our labor unions have recognized the desirability of organized labor participation in the safety movement. Some have become joint participants with the employer groups in conducting industry-wide safety programs. Many provide safety instruction materials for their members and participate with other organizations in safety research and in the development of safety standards.

23. Two great advances in accident prevention were accomplished when the National Fire Protection Association was organized in 1896 and the American Standards Association was organized in 1918. Prior to the formation of these voluntary privately financed organizations, safety rules and guidelines, and safety legislation as well, varied widely among different industries and among the different States. Both of these organizations moved quickly into the safety field and began to produce safety standards which reflected the best thinking in the country. Because of their excellence, these standards have received wide acceptance throughout the United States. Individual establishments and many whole industries have adopted them as a part of their operating rules, and many of our lawmaking bodies have enacted them into laws or regulations. These are primarily engineering standards relating to the construction and maintenance of safe workplaces, the guarding of hazardous equipment, the elimination of hazardous environmental conditions, and the safe handling of hazardous materials.

24. It has long been recognized in the United States that work-accidents are extremely costly events not only in terms of human resources, but also in terms of material and equipment losses and reduced productive efficiency. A safe plant is usually an efficient establishment with a high standing as a good place to work. Establishments with poor accident records have learned, to their sorrow, that the efficiency of their workers declines after each accident, their competitive position is weakened, their employees are dissatisfied, and it is difficult to persuade the most desirable persons to accept employment with them. Management accepts the concept that safety is good business and not simply a humanitarian activity or an annoying requirement imposed by law or pressure from employee groups. Accident prevention has become an integral part of management and the specialists who administer plant or company safety programs commonly report directly to top management persons.

25. These accident-prevention specialists, who like to call themselves safety engineers, even though many have had no engineering training, take great pride in their profession. For them the achievement of safety is the first objective of any business enterprise. They are true zealots working to improve the lot of their fellow men. To further their efforts they have banded together in a national professional society dedicated to the advancement of safety. Through this organization, The American Society of Safety Engineers, they enhance their own abilities through applied research and the exchange of ideas on accident prevention. Equally important, they act in concert to promote interest and respect for accident prevention in all segmnts of the population. Largely through their efforts, instruction in safety has become a part of the training offered in most engineering and trade schools. They now have over 7,200 members in their voluntary organization.

26. These widely diverse groups working together in a common cause as the American Occupational Safety Movement have achieved magnificent results. They have carried the message of occupational safety throughout industry and into the homes of our workers. One of the most effective techniques has been to stimulate the interest of each breadwinner's family in his personal safety. Through this family persuasion approach many workers have been convinced that to take a chance is simply foolhardy, and much greater worker acceptance of safety rules and procedures has been achieved. Significantly, it has been found that scare stories presenting the horrors of work injury are generally less effective in creating interest in safety than are reminders of the benefits of remaining uninjured. Equally significant, our occupational safety movement, at the instigation of the management groups, is extending its efforts to include the promotion of "off-the-job" safety. Actually, today in the United States more workers are killed and injured in accidents away from work than while in the course of their employment.

27. The justification for these extensive efforts to achieve occupational safety lies, of course, in the results obtained. Here we have abundant evidence of success. In the steel industry where the first organized safety efforts were established, a group of safety minded plants reduced their joint work-injury frequency rate from 60.3 disabling injuries in every million employee hours worked in 1913 to 8.2 in 1925. In 1961, our entire iron and steel industry had an injury-frequency rate of only 3.3. This was not just happenstance in an isolated industry. Some 21 of the 138 manufacturing industries for which we have current records had injury-frequency rates of less than five disabling injuries per million employee hours worked in 1961. For manufacturing as a whole, the 1961 frequency rate was only 11.0, a tremendous reduction from the level of 20.0 which prevailed only a few years ago in 1943. Many individual establishments have achieved records exceeding 1 million employee hours worked without a single disabling injury to any employee.

28. These statistical records not only prove the worth of the accident prevention movement, but provide the encouragement and stimulus for its continuance and expansion. In this respect injury statistics are essential tools of the safety movement. Without some measure of success or failure, interest in safety would lag and the safety movement would wither. The statistical needs of the safety

movement, however, extend far beyond these simple measures of progress. Through statistical analysis of the circumstances and conditions associated with accidents, we can determine the general pattern of accident causes and indicate precisely what kinds of accident-prevention actions are most needed. With this information at hand, those who have responsibility for direct accident prevention can plan their programs effectively and avoid much wasted effort. From such studies we know that we have in the United States reduced machine accidents to a point where our greatest efforts now need to be concentrated upon eliminating slips, falls, and material-handling accidents. These, incidentally, generally result from circumstances which cannot effectively be covered by law or government regulation. They must be brought under control by management and employees working together for a common purpose. Here we feel that management must lead, but without employee cooperation the effort will fail.

29. The most significant elements in our experience for consideration by the newly developing areas in combatting work accidents, therefore, rest on the basic premise that work safety is a matter of interest to everyone. Government certainly must participate by providing leadership and minimum safety requirements. And government probably should assume the function of compiling and distributing the essential statistics.

30. But government cannot do the whole job alone. True progress in safety requires the support and active participation of all sectors of the economy. It must be promoted and encouraged in the home, in the schools, in worker and management groups, and through specialized private organizations. The safety standards we have developed and the methods we have applied in promoting safety are available for the asking. But success in achieving work safety comes only when everyone concerned is convinced that it can be accomplished and that it is worth the effort.

PART II

TRAINING OF SCIENTIFIC AND TECHNICAL PERSONNEL

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Introduction

The papers which follow are an attempt to make available to countries less developed than the United States the experience of this country in striving to improve our techniques for the training of scientific personnel. In the main, the papers are descriptive rather than hortatory. They are a record of a concerted and organized attempt to define goals and develop programs to reach these goals.

This is not a success story. It is rather a history of trial and error leading finally to a program of action, the components of which have been well tested and the results of which are highly promising. But it is a story written in mid-course. We have a long way to go before we can present ourselves as a model for other countries which want, as we do, to select the people best fitted for training in science and technology and to see that they get the best possible training.

The authors of these papers have differing backgrounds. One, Dr. Ralph Tyler, trained as a psychologist, is one of the elder statesmen of American education and has for three decades been a major force in the improvement of teaching at all levels. Another, Dr. Jerome Wiesner, has forsaken teaching and research for the time being to serve as the President's chief adviser on science and technology. Two others, Drs. Kelly and Dees, both physicists, have for almost 10 years carried a heavy responsibility for the wise investment of the substantial sums appropriated by the Congress for the selection and training of scientists and for the improvement of the teaching of science.

But though their backgrounds are different, the authors of these papers have much in common. Like St. Paul, they speak of things part of which they were and all of which they saw. They share a sense of urgency about the necessity of solving the complex problem of optimum utilization of our limited manpower resources in the various fields of science. They also have in common that American optimism which has impressed foreign visitors from de Tocqueville to Gunnar Myrdal that any problem which can be defined can also be solved. It is this optimism, one of our most blessed American traits, which has led these men to devote some or all of their energies—as civil servants, officers of private scientific agencies or government consultants—to defining our national goals with respect to the sciences and to the invention of techniques and programs calculated to help us reach these goals.

I use the word invention deliberately. Many of the programs described by Dr. Dees and Dr. Mayor are as truly inventions as was the steam engine or the airplane. And like the steam engine and the airplane, they are the product of long study and much experimentation.

As I have suggested earlier, we in the United States have made substantial progress in our campaign to improve the selection and training of scientific and technical personnel, although the goal is still a distant one. The byproducts have been singularly important. The massive effort to improve the teaching of science has inevitably caused us to take a hard look at our whole educational system and to consider whether the teaching of all subjects at all levels cannot be made more rational and more efficient. As this volume is being published, both the behavioral scientists and the humanists are launching programs to improve teaching in their various disciplines and to re-think their curricula.

As both Dr. Kelly and Dr. Zacharias point out, the effort to improve training of scientists and technologists has required a redefinition of subject matter in all the sciences, as well as a review of our teaching methods and our selection procedures. Dr. Zacharias' case history of the program to redefine and reconstruct the secondary school curriculum in physics is illustrative of similar programs in mathematics, biology, and chemistry, which are now well advanced, and other efforts in sociology, economics and anthropology, which are just beginning.

One of the most happy results of these efforts is that they have forced the building of bridges over the wide chasm that has heretofore separated elementary and secondary education from higher education. The scholars whose task has been to redefine and reorder the teaching materials in their several disciplines have discovered, as Dr. Mayor points out, that they could do their work intelligently only with the cooperation of the teachers who must use the new materials. The teachers in turn have discovered that they themselves must learn the new science before they could hope to transmit it to their students. Thus the whole effort has produced increased communication and increased understanding between the bottom, the top, and the middle of our highly complex educational system.

Many of those who read this volume will be familiar with the structure of American education. Others will have to derive it from these papers. Perhaps the most marked characteristics of our educational establishment are its diversity and its lack of centralized control. We have no ministry of education in the United States and even our state superintendents of instruction have only very limited control over what goes on in the schools of their respective states. No order from Washington nor any ukase issued from the Capitol of one of the 50 states can force innovations on our schools, colleges and universities. The effort to improve is and must be a wholly voluntary effort, in the teaching of science as well as in other sectors of education.

If at times this seems to hinder the pace of desirable change, it has the great virtue of generating wholehearted support for new ways of doing things which have been proven to be better than old ways. It also helps us to avoid the hazard of inflicting on any area of the country patterns of educational activity unsuited to its cultural traditions and to its peculiar local conditions.

I think it fair to say that this is not a didactic book. It offers no formulae guaranteed to produce in any circumstances a quick and drastic improvement in the processes of selecting and training scientific personnel. It is, rather, an attempt to share what we have learned and an invitation to other nations to join with us in a continuing effort to improve education in the sciences. The warning that Dr. Kelly sounds against transmitting our prejudices to other countries rather than transmitting the lessons we have learned echoes throughout the other papers. Dr. Wiesner points out the hazards involved for less developed countries in sending their ablest young men abroad for training in the sciences and emphasizes the importance of developing strong university centers all over the world. In similar vein, the three distinguished representatives of the publishing industry urge that every country develop the capacity to produce its own textbooks.

The authors of these papers all have that humility that comes from occasional failure and that capacity for the tentative statement which is the common characteristic of men who have discovered that they can be wrong.

But if this is not a didactic book it is in the true sense of the word an evangelical one. Through all these papers runs our American faith in science as a means to the more abundant life. This is an older faith than some of our critics assume. It is not a product of our successful attempt to split the atom, nor of our effort of the last 15 years to improve our defensive posture by a huge program of basic and applied research. Our faith in science is part of our heritage and rests primarily on the repeated discovery that science can help us to lead healthier and happier lives. The milestones along the route are not the invention of new weapons but the victories over famine, disease, and ignorance.

There is another older American faith that underlies our faith in science. It is our faith in education as a means of improving our common life and our individual welfare. At times this faith must seem naive to our friends in other countries. Our willingness to tax our incomes, our lands, and our chattels at heavy rates to support schools of all kinds; our insistence, imbedded in law, that our young people must have as much education as they are capable of using; our feeling that illiteracy is one of the seven deadly sins—all these provoke something between amazement and bewilderment in our friends abroad. But they appear more rational and more necessary if one believes, as we do, that an educated society is the only kind of society that can tolerate democracy.

A summary statement of the American credo with respect to education will be found in the concluding sentence of Dr. Wiesner's eloquent paper: "A good educational system may be the flower of economic development but it is also the seed."

As a people we believe that education is the means, perhaps the only means, to the more abundant life. These papers record one important expression of that belief.

CHARLES DOLLARD,
Chairman, Advisory Committee on International Science Activities,
National Science Foundation.

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Planning Policies for Development of Scientific and Technological Personnel

Planning Policies for Investing in Scientific and Technological Education*

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1. Until this United Nations conference, a landmark for us all, we have never tried to assemble in one place and at one time the lessons learned about the role of science and technology in the human and material advancement of people and of states; and we have never tried seriously to lay out the full sweep of the opportunities for advancement offered by science and technology.

2. My country is firmly committed to the goal of assisting, in the words of the title of the Conference, the "less developed areas," as they strive for the development and the political stability that depend so much on economic strength and security. I believe that stable political conditions will prevail only after we have achieved freedom, literacy, and economic well-being for all the peoples of the world—economic development is a mockery unless it is accompanied by peace and political independence. For a number of years, the United States has devoted approximately $4 billion a year to direct assistance, in one form or another, to developing countries and, what

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*UN conference paper.

is more important, a good proportion of our scientific manpower. It is of the greatest importance that this assistance be wisely directed and that it contribute to thoughtful planning by the nations themselves for wise use of their own resources.

3. We in the United States have engaged in extensive studies, alone and with the less developed nations, to understand better the role of science and technology in economic development. But this conference provides an unparalleled opportunity to discuss the ideas and experience of all nations. It offers the best possible framework—the United Nations—for such discussion. And it offers us all the chance to meet together on the subject of the advancement and well-being of people everywhere, apart from political and military issues.

4. The subject of this Session, where the United States has as much to learn as other nations, illustrates another reason for welcoming this conference. The problem of providing an adequate supply of well-trained manpower requires an enormous amount of attention in all countries, and appears to be among the hardest to solve. In my post in the United States I find that I must devote a great amount of effort to the question as it applies to our needs. I have come to the same conclusion that all must reach when considering this problem: The need for scientific and technical manpower is greatly increasing, and we will have an extremely difficult problem in meeting that need in time. General education and special training are the key elements in the economic and social development of all nations and require the personal attention of political leaders and planners. Education *cannot* be left to last, as has been done in too many instances, as something that can be attended to after other needs are satisfied.

5. Although the specific problems of education and manpower vary from country to country, the basic principles of what constitutes a good education are much the same everywhere. The exchange of experience and ideas in this Session should provide all countries, economically advanced or in the early stages of development, with information and suggestions applicable to their own needs.

6. It will be useful as background for this Session, and to emphasize the points planners concerned with education must keep in mind, to state some of the important roles I see for education in any nation. First is the need for general literacy. Education is needed to create an informed citizenry; to make it possible for individuals to develop their capacities to the fullest; to provide a consensus or sense of unity in a society (by this I do not mean conformity); and, in the phrase of Dr. Max Millikan in an address at Oxford University, to provide a "search and selection device" to enable those best qualified to move into the professional, technical, administrative, and political roles.

7. The most obvious purpose of scientific or technical education in this context is to turn out people with the skills needed to make a modern society work. Special skills are needed for everything from operating a modern power plant, to running a government ministry, to using new fertilizers, or to using bank credit. There are hundreds of skills which may be alien to a traditional society but which may be necessary for the successful introduction of new technology.

8. A further word is in order concerning these skills. All too often when education is discussed, it is tacitly assumed

that all you need are training courses to turn out technicians able to operate this piece of machinery or that kind of equipment. The one thing we have surely learned during the past decade is that modern technology and agriculture cannot be transferred intact from one environment to another. Further, the rate of technological change is so fast that people must be able to adapt successfully to new situations. What we must create through education is a sense of innovation and inventiveness and a flexibility of approach to new situations. We must do this at all levels of education so that the new technologies can be adapted to local environments and society itself can help to create the technology and organization it needs. In the United States we have become conscious of similar needs for education. We have some interesting programs underway for improving instruction in engineering and science in college, as well as for improving instruction in science and mathematics in elementary and secondary schools. These programs will be discussed in the specialized sessions, but I know that many are already familiar with them, since cooperative programs are in progress to adapt our new materials and techniques for use in parts of Africa, Asia, Latin America, and Europe.

9. I should like to call attention to two other roles for education pertaining to science and technology. One is the set of attitudes that the teaching of science can serve to instill. Science has been the dominant force shaping our lives in this century, not only through what we have learned but also through the changes in attitude the progress of science has brought about. One of the most significant lessons of science, for example, is that the physical world around us is understandable and can be molded to serve man's requirements. Furthermore, the behavioral sciences are now beginning to provide insights into man himself that should in the long run help to bridge the gaps between the various cultures and social systems of today. The teaching of science, therefore, can have a major impact on an individual's attitude towards his environment—the physical and often the social and political. Traditional barriers to progress—to the physical and social development of a society—cannot withstand the new attitudes that the study of the sciences can instill.

10. Thus, science education can be a powerful force for change, but, it must be added, only *if the science education is adequate*. There are "traditional" methods of teaching science which will have little effect in developing this attitude of mind and little useful effect in the teaching of science itself, for that matter.

11. The other point worthy of special mention is that a society should insure that its educational system will represent its best intellectual effort. We live for more than material progress; we must live ultimately for societies that make possible a sense of fulfillment for all. This sense of fulfillment must be realized at all levels, but the highest level of the educational system is especially important because it sets the goals for the future of the whole educational system and hence for the future of the nation. You cannot have a truncated educational system and still meet future needs for growth, change, and intellectual challenge. Science plays an important part in this, for fundamental research is one of man's noblest intellectual endeavors; to neglect it on any grounds, but particularly

on the ground of irrelevance to a nation's growth, is in my estimation sheer folly.

12. In this respect one could point to the experience of my own country, where in recent years our emphasis on science, and especially on basic research, has helped to create an intellectual ferment and excitement in all intellectual fields and has contributed greatly to our economic progress. We have no monopoly on basic research, and want none. Science affects all, belongs to all, and is needed by all.

13. So far this paper has presented the general requirements that need to be satisfied by an educational system in any country, and thus some of the goals a government needs to keep in mind in deciding on the form, character, and size of its investment in education, and particularly in scientific and technological education. Of course, the translation of these general ideas into specific plans is an extremely difficult task, difficult in different ways in each country. Many specific questions are discussed in the specialized papers to be presented at the Conference, but I propose here, as background for those papers, to point out some of the principal problems governments face, with some indications of my own estimates of priorities and important issues.

14. The first question to arise in any country, but with special severity in one which is less developed, is how the nation can mount quickly the massive educational programs that the government feels are needed and which the people are demanding. In general, the limiting factor, more than money, is the supply of trained teachers, from the primary school through the university and adult education programs. In parts of the world which have not previously had sizable educational systems, much of Africa for instance, the requirements in sheer numbers are staggering.

15. These countries not only face a demand for an enormous expansion of an educational system in an extremely short time, but also are badgered with advice from all sides to emphasize quality over quantity, to support expensive research, to concentrate on centers of excellence, and so forth. How should these competing demands be balanced? Where is the appropriate starting point? What is the order of priority? How great a share of a nation's scarce resources should be claimed by education?

16. There are, of course, no general answers to these questions, and perhaps not even any "right" answers on a national basis. Primarily, the decisions are a matter of informed judgments, drawing on experience and advice where available. It is worth mentioning some of the recent work that attempts to relate in quantitative terms investment in education to economic growth. These studies, many of them carried out under the auspices of the Organization for Economic Cooperation and Development, may produce better guidelines in the future than exist at present for the appropriate level of investment in education in relation to competing demands for resources.

17. One conclusion to be drawn from the large gap in most countries between demand for education and available educational resources is that innovation in educational methods is needed. There is nothing sacrosanct about existing patterns of education in the Americas, Europe, or any other region. By and large, they were developed in a different era to meet different needs. Education today should instill a sense of innovation and a willingness to approach problems with a fresh and unprejudiced point of view, and we should be prepared to ap-

proach education itself in the same fashion. And as I have said before, this is not a problem unique to the less developed countries, for we in the United States have realized that moderate, and sometimes drastic, change is necessary in our system if it is to continue to serve our country and our people. We have started an overhaul of our own in the sciences, and are beginning to extend it to other subjects as well. We have found widespread acceptance of our new approaches in United States schools and considerable interest in other countries.

18. There is another conclusion to be drawn from the work that we and others have done on educational problems recently: there are developments under way that could change greatly our concepts of teaching and even shorten the period necessary to accomplish our teaching goals. Some of the ideas embrace more extensive use of the full arsenal of teaching aids—books, film, radio, television, teaching machines; others question our present attitudes toward the learning abilities of our children. Some of these studies can be classified only as research into teaching; others involve the development of new curriculum materials for specific subjects. It seems imperative that the less developed countries be aware of these developments, and participate fully in them. These new ideas provide a hope, perhaps the only hope, for educating a large number of students with an inadequate supply of teachers.

19. Some people believe that traditional science curricula are adequate for the developing countries and that the introduction of the new course material and teaching methods can come later. This is much like saying that to grow technically and economically a new state must go through all the stages that the Western countries went through, repeating everything, including mistakes. In a country with limited resources and less time, only the most modern materials should be tolerated. There should not be one kind of physics or biology or chemistry or mathematics for the mature countries and another for the countries striving to build a scientific base for their economies—although, of course, materials may have to be adapted to local conditions, in biology, for example, to local fauna and flora. The best should be available to all.

20. I have assumed in this paper that an educational system would include science and technology in primary school, not just in secondary school and college and technical school. This idea is not universally accepted, except, of course, that few would argue against quite early teaching of arithmetic, and perhaps a little biology. In fact, I would plead for extensive programs in science, including, of course, mathematics, at the primary school level for two major reasons. First, I have become convinced that the children can study these subjects with profit and enjoyment, and second I believe, as stated before, that scientific education can be important in imparting a favorable attitude toward change.

21. The question of relative emphasis in education on universal primary school education vs. the secondary school vs. the university, will not be discussed here—so much depends on the local situation. But some remarks about the needs of universities, especially in relation to science and technology, are in order.

22. No matter what priority is accorded primary or secondary school, resources must be found for the university system. I do not believe a nation can produce the manpower for a complex society without a good university system.

Without native manpower, industrialization, agricultural and health measures, and other forms of economic and social investment cannot become an integral part of a nation's economy. This is not a matter simply of training a few people. Rather, it is necessary to provide a cadre of scientists and engineers who can understand developments in other countries and relate those developments to the situation in their own country. Outside experts can help, but someone has to ask the right expert to help, and the act of asking presupposes a person in the country who already has a good understanding of the problem. Subsequently, the expert must be able to communicate his ideas to a person who can understand them, who can modify them according to local conditions, and who can carry them out.

23. Developing scientists and engineers is almost entirely the job of the university system. And here again I would say that a country that believes it can solve the problem entirely by sending its people abroad for university education is making a mistake. The cost of sending students abroad is high, and the education they obtain often is not sufficiently tied to their country's needs. Of at least comparable importance is the fact that the intellectual leadership, the critical examination of issues, the challenge to convenient solutions, the espousal of new ideas, have traditionally depended upon the faculties of strong universities. A society that lacks this element lacks an ingredient basic to freedom and progress.

24. Last year some 60,000 students came to American colleges and universities from abroad; this is a large number and we hope to see it grow larger. In addition, we are instituting programs at some of our best universities that will emphasize the technical problems of the less developed areas more than we have in the past, thus relating the education a visiting student will receive more closely to his own situation. And this will be done without segregating our foreign students from the main stream of American student life. Yet, while we would like to see the number of foreign students in our country increase, we believe at the same time that it should be a small percentage of the number of the students in the universities back home. Only at the graduate level in research, where research experience in leading laboratories can be an important, even necessary, part of scientific preparation, should foreign education remain a major factor in the educational development program.

25. There are other reasons besides cost and kind of education for developing a strong university system. One is the need for a nation to be able eventually to satisfy its own trained manpower needs, and this undertaking requires a start in that direction right now, regardless of the present adequacy of the primary and secondary school systems. Another is the simple fact that all parts of an educational system depend on each other, and that a complete spectrum is required, including the research level, in order to provide the intellectual challenge and up-to-date content throughout the educational system. A third reason is that applied research in fields such as health, agriculture, mineral location and exploitation, is done best only in the country itself. This is the job primarily of the universities. And, finally, there is the more philosophical justification already mentioned that no nation can be willing to relegate itself to second-class status by voluntarily eschewing the highest forms of intellectual endeavor.

26. A commitment to a first-class university system including scientific and

technological education is fine, but once made it raises various practical questions concerning just how much can actually be done. Can a nation realistically encourage the development of first-class teaching and research in all scientific disciplines? Must it provide the resources for any and all who desire to go on for a scientific career? Is there a balance that should be achieved between basic and applied research?

27. It is clear that a nation with limited resources simply cannot provide the facilities for all scientific fields. On the other hand, deciding which fields to emphasize is extremely difficult; enforcing such decisions is also difficult, especially if outstandingly competent individuals would emigrate if not given the means to pursue the subjects of their choice. Once again, there are no simple guidelines to making these choices; decisions will have to be guided by common sense, coupled with sensitivity to local problems. Clearly, consideration should be given to activities which have relevance to local problems, but not at the cost of eliminating potentially outstanding efforts in which there is no predictable direct impact. Perhaps the best way to approach the question is to counsel overt encouragement of research and education in those subject areas most closely related to economic development, such as geophysics and the health and agricultural sciences, and to stand prepared with limited resources to respond to requests from universities and individuals who want to do advanced work in more theoretical sciences, such as physics and mathematics. In my country, where we have tried to maintain excellence in science across the board, we are forced to give increasing attention to the problems of balance as we run up against severe manpower shortages and skyrocketing costs of research activities.

28. One comment from my own limited observation is that I have yet to visit a country in which, in my opinion, the resources devoted to science and technology in the universities were adequate to the needs. This is particularly true in the developing countries, where the immediate problems of development are almost overwhelming.

29. Another policy question frequently arising in the planning context is how best to develop a higher education and research system. Should support be provided for all existing universities, whether good or bad, with the goal of building a strong, broad base? Or should support be limited to those centers that already have established their competence and have appropriate attitudes towards research and education? Here the experience in the United States, and in many other places, is relevant: it is essential to concentrate on the centers of excellence to enable them to expand and to train more people. To choose otherwise would, I believe, result in a second-class university system. This, of course, leads to some very hard decisions, for it can mean developing one or a few centers in one part of a country to the exclusion of others. Still, I believe that with limited resources, or even with plentiful resources for that matter, this is the wise course.

30. It is toward the development of centers of excellence that the more advanced countries can make major contributions through their own systems. These countries can help by offering graduate training, by making available senior people for periods of time to assist directly in the teaching and research programs, and by providing some funds for equipment, texts, and the like, once the national government has made a commit-

ment to develop certain institutions. In addition, cooperative arrangements on a university-to-university basis, such as exist now between American universities and some 100 universities and university departments around the world, can provide important intimate support and scientific assistance.

31. Let me close by repeating once again my conviction that education broadly, and scientific and technological education specifically, are critical factors in the economic and social development of every nation. A good educational system may be the flower of economic development, but it is also the seed.

Programming of Science and Technology Within the Educational Structure *

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1. The educational tasks required for a country to utilize fully the potential contributions of science and technology include the development of public understanding of science and technology and the preparation of technicians, of scientists and engineers, and of teachers.

(a) The importance of public understanding is often overlooked. People who are not themselves scientists, engineers, technicians or teachers are nonetheless involved in scientific and technological development.

(i) In the first place, they are consumers of the products of technology which are often different in appearance or in other respects from those previously used. For example, in utilizing science and technology to provide a greater quantity of food with more adequate nutritive value, new food products are being developed which are made from different raw materials and which have different tastes from the foods heretofore comprising the basic diet of the people. Unless they understand fundamental notions of human nutrition and the scientific basis for selecting and producing the new foods they will not eat them. As another illustration, in utilizing science and technology to improve the health of the people, new sanitary practices are recommended and new medical and technical personnel and institutions are being developed. Unless the people understand fundamental concepts of physiology, ecology and hygiene, they do not willingly change their personal habits.

(ii) In the second place, the productive activities of the people in almost every walk of life need to be changed or modified in order to benefit fully from the results of science and technology. This is not limited to factory workers and technicians. Thus, many farmers will need to grow different plants using new seed, to raise different animals using new stock, to cultivate the soil differently, to control pests in new ways, to feed animals differently if they are to increase their production markedly. This means that they must understand something of the basic notions of agricultural science. As another example, carpenters can greatly increase their productivity through the use of new tools

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*UN conference paper.

(hammers, saws, drills, measuring instruments, etc.) and new materials (plastics, concrete, metals, fabricated plant and mineral products). Selection and use of these tools and materials to maximize productivity require some understanding of their nature and of the rationale for their efficient use.

(iii) In the third place, the people need to understand the nature of science and technology, what they require for their development, what their contributions can be, and what kinds of economic, social, psychological, and aesthetic effects they may engender in order to participate intelligently in the decisions required in the nation and in the local community to make full use of them in economic development. Decisions of this sort have repercussions throughout the nation on the lives of the people. Unless an informed consensus is reached among the people, they fail to support needed actions and resist steps which are essential in the development process. Thus, they may favor immediate increases in consumption goods and fail to give adequate support to education, research and development, and other capital expenditures. Or they may push for the construction of nuclear reactors, large factories, and other spectacular physical plants at the expense of investments in education, in tools which can be quickly utilized for increased production and for other less impressive means for employing science and technology.

(iv) Finally, public understanding of the dynamic nature of science and technology is necessary because totally new patterns of life careers are involved in their full utilization. In the traditional society, one's occupation was something on which he entered in his youth or in early adulthood and he continued in it until too old or otherwise incapacitated. A few changes might take place in the procedures of the occupation, but the basic pattern of activity of farmer, weaver, carpenter, cook, etc. remained static throughout his life. Historically the first impact of technology was to shift occupations from one generation to another. When hand weaving was replaced by the textile mill, the children of weavers became mill workers. Few of the weavers attempted to develop new skills in order to enter into a new occupation. Similarly, in the United States when the production of machines was largely shifted from the handicraft of mechanics to the factory assembly line, few mechanics undertook the learning of a new trade but their children went on through high school and often into colleges or engineering schools to prepare themselves for engineering, science, medicine, law, or business. As farming in the United States increasingly utilized science and technology the size of the farm labor force was greatly reduced while farm productivity was greatly increased. Few farmers learned new occupations but a majority of their children did. Now, however, science and technology are developing so rapidly that if a nation wishes to make full use of them many occupations must change greatly and quickly or be eliminated, and many new occupations emerge. This cycle of change grows faster, so that it is safe to predict that in a country making full use of science and technology, a majority of people can expect to be employed in more than one occupation during their lifetime. This is such a change in tradition that direct efforts must be made to help people understand what is happening and appreciate the importance of cultivating flexibility and of learning new skills and new occupations in order to derive many of the potential benefits of science.

(b) The preparation of technicians is an essential part of the development of the working force required to operate a developing economy. More attention is commonly given to the education of scientists and engineers because they are responsible for the guiding ideas and design of development processes. But their efforts require the supporting contributions of technicians. These are the persons who make, install, and repair tools and apparatus, who prepare drawings and maps and make photographs, and who do many kinds of work directed by scientists and engineers but which do not require the full extent of professional knowledge and skills. Typically each scientist and engineer can effectively utilize the services of from 5 to 15 technicians.

(c) The preparation of scientists, engineers and other professionals is the task which draws heavily upon the institutions of higher education. These are not simply people with technical skills who are familiar with current practices in industrial countries. They are persons who have basic knowledge of science and are skillful in conducting inquiry, directed both at expanding their basic knowledge and solving the new problems which are always arising in the process of developing a more productive and efficient economy through the use of the knowledge and methods of science. The task, therefore, is to prepare scientists who are able to develop new and relevant knowledge and to use their knowledge in the solution of pressing problems such as those in the fields of health, of material production and distribution, and of communication. An equally important job is to train engineers who can analyze the problems, assess the resources available and design systems which aid in the solution of the problems. Mathematicians must also be prepared. Sometimes the role of mathematicians in the group of important professionals is not recognized. They are basic to the intellectual activity both of scientists and engineers so that provision for their education is essential. Health scientists are also necessary including not only the physician and the sanitarian but also those who study the health problems of the country seeking solutions through research. This brief listing of needed professional personnel should indicate that this is an important cadre in the total national effort although much smaller in number than the large body of technicians.

(d) The preparation of teachers of science and technology is probably the most crucial task confronting any nation seeking rapid development. Its importance lies in the fact that the effectiveness of the teacher largely determines how well the educational responsibilities previously mentioned are met. The teacher not only influences what the students learn and how much they learn but also the choices they make of occupations and of further education. The difficulty of the task lies in the complex requirements of a good teacher, the relatively large numbers needed to provide for public understanding and for specialized preparation and the inevitable competition for people trained in science between employment as scientists and employment as teachers. In the initial stages of development only a few people will have come through the necessary scientific education of the secondary school, far fewer than the number that could be very effectively used as scientists or engineers. It is difficult for a nation to make the decision that a considerable fraction of this group shall be prepared to be teachers rather than utilized in the practice of science or engineering. But without an adequate supply of competent teachers the needs for professionals, for technicians, and for public understanding will not be met.

2. The educational program for the development of public understanding of science and technology should include efforts to reach adults through meetings, demonstrations, museum exhibits, books, pamphlets, articles in magazines and newspapers, television, radio and motion pictures as well as formal adult courses. However, in this paper the concern is with the curriculum of the school and no explicit treatment is given to the necessary education of adults.

(a) The purpose is to develop in all children and youth the knowledge, attitudes, and habits required to utilize science and technology fully and effectively in the economic development of the nation. It is not limited to those whose special interests and aptitudes would lead them into scientific and engineering occupations. Its aims should be to develop in the students an understanding of the nature of science and technology, an understanding of the contributions of science and technology and their social effects, attitudes characteristic of a scientific outlook, including willingness to make necessary changes in the ways of working and living which seem in scientific terms to be more productive or more healthful than the previous ways and habits in harmony with this understanding and these attitudes.

(i) Currently the uninformed public thinks of science and technology in terms of a specific set of devices and practices—the motor car, the television set, the clerk and factory worker. Science is commonly viewed as having definite answers to all major questions, a kind of modern magic. Unfortunately, much of our earlier school instruction in science did not develop a greatly different view, but simply filled in bits of information and terminology within this kind of picture. What is needed in developing public understanding is to perceive science as a process of continuing inquiry, depending upon observation, rational processes, naturalistic notions of cause and effect, and possibilities of thus explaining phenomena and predicting the outcome of specified events. Science seeks to answer questions but in the process of scientific investigation, while tentative answers are often obtained to the questions with which the inquiry began, new questions arise, new data are observed, new explanations are worked out, so the inquiry goes on. It is never completed but it usually expands and deepens our understanding. Correspondingly, technology needs to be viewed by the public as ingenious invention and development by which scientific knowledge is put to work in accomplishing some of men's purposes. Thus, scientific knowledge about electricity was put to work by the invention of electric generators and electric motors. Scientific knowledge about genetics and about plant ecology was used to develop new strains of plants which could survive the limited rainfall of arid regions. Each technological device is a man-made product and is often superseded by another invention which serves men's purposes more effectively and efficiently than the previous one. Scientific inquiries are continually expanding and changing our knowledge. Technology is continually expanding and changing both because of new knowledge and because of new inventions which improve upon the earlier ones. It is this view of the nature of science and technology that is required by the people if they are to understand the need for continuing scientific research, for continuing efforts at technological inventions and improvements, and for continuing study on their part to keep abreast of major developments.

(ii) Closely related to the need for all people to understand the nature of science and technology is the need to know of their effects, both the social contributions and the undesirable consequences. Science as a way of thinking and of solving problems gives man a new hope that he can work out the solutions to problems which have heretofore seemed beyond his capacity to deal with. Many diseases are being brought under control, man's life is being lengthened, much heavy labor is being taken off his shoulders, production is being greatly increased. But these possibilities have important disturbing consequences. As he gains new powers, he faces the need of greater self-discipline in the use of these powers. For example, no longer does the sheer limitation of the food supply control his diet. He must control himself in the selection of food as to both quantity and type. No longer do disease and famine need to determine the size of his family. He is now responsible. No longer does the limitation of books, magazines, movies, television and radio determine whether or not he continues to study and learn. He must discipline himself to make constructive use of greater opportunities. Furthermore, as man gains greater control of his environment, his traditional beliefs, including many of his religious beliefs, will appear to him to be in conflict with new knowledge thereby creating contradictions which he will have to resolve. A serious result of technological development is the pressing demand for new skills on the part of those who operate and use new devices and the consequent obsolescence in skills which were required before the new devices were employed. This places upon man continuing requirements for learning, for changing his activities, and for other related readjustments. Finally, people need to understand that the employment of new technological devices will sometimes produce unintended, undesirable outcomes. For example, the rapid increase in the use of motor cars has greatly increased the accident rate, and in crowded areas has produced heavy smog. As another example the use of weed killers in agriculture has also destroyed beneficial plants and animals. Technological inventions should be recognized as having potential both for good and evil. People need to understand the importance of assessing the probable consequences before widespread adoption of a particular device and to recognize the importance of making later assessments of the results as the devices are in use.

(iii) The nature of science and technology and their social effects suggest the kind of attitudes required which are both consistent with the understanding people have and are helpful in promoting economic development. The term "attitude" is used here to refer to the emotional quality accompanying one's understanding of the phenomena. Some of the important attitudes characteristic of a scientific outlook are: an interest in new knowledge and in the utilization of new knowledge, an expectation of change in one's life and in the society as new knowledge and new technology develop, an objective view of matters about which different explanations and proposals are made, a concern with consequences of actions rather than a concern with the propriety of actions in themselves. With attitudes like these, people are able to accept new knowledge and to seek ways of employing the knowledge productively. They are able to make changes in their own lives and to support national and local policies which utilize science and technology effectively. Without such attitudes, the people will be unwilling to use many of the new developments in their own lives and will resist national and local efforts to utilize science and technology fully.

(iv) The importance of developing habits which are supportive of the understanding and the attitudes outlined above lies in the fact that habits developed in youth strongly influence one's later development. If, during the school years, the student acquires the habit of reading and study and conducting small inquiries, he will probably continue this practice throughout his lifetime. If he develops the habit of selecting food in terms of what he knows of its nutritive value, this, too, can be expected to continue long into adult life. If he forms the habit of trying to use new knowledge and new devices where he finds they improve his own work, he is likely to continue this practice. If he acquires the habit in school of studying proposed national or local policies in terms of their effective utilization of science and technology, this will probably become a continuing basis for his supporting or not supporting such proposals. Hence, the development of habits is an essential part of the educational task.

(b) To attain these important aims, which are involved in helping all people to develop public understanding of science and technology is not easy. It requires an educational program for this purpose which is an integral part of the school curriculum beginning with the primary grades and extending through all the grades of the common school. For young children the emphasis is placed on observation of natural phenomena in their own environment, discussing what they have observed and raising questions for further study. By beginning with very simple illustrations, the children are involved in thinking in terms of cause and effect and in using a few basic scientific concepts to explain what they observe. At this age children are able to listen to brief stories of scientists, how they work, and what they discover. It is important that both the observations and the reading exemplify accurately the nature of science and technology in simple form. Even at this young age, children should be participating in the rudiments of scientific inquiry, and making simple applications and inventions. In this way they learn to understand the nature of science and technology, not by being told what they are but by their own experience in them. These kinds of activities, growing gradually more complex, are continued as the children grow older and move into the upper grades of the common school. A similar type of approach is used in helping children to understand the contributions of science and technology and their social effects, drawing upon the opportunities available in the children's environment and building on them with materials which describe other illustrations. The school situation should be planned and conducted so that children will have the chance to make many applications of science and technology in their life at the school, and they should also be encouraged to make applications habitually both within and without the school. The important points are to provide for these activities in every year of the common school and to make the course in each year an honest representation of science and technology in which the children themselves are involved as thinkers and actors.

3. The preparation of technicians will require for some years to come a program for the training of adults who have been engaged in other occupations as well as a program for educating youth for this work. However, the concern of this paper is the school curriculum rather than the retraining task with adults.

(a) Since technicians serve to aid, apply, and extend the work of scientists and engineers, the number needed at any given time is a multiple of the number of scientists and engineers employed at that time. Typically, the number of technicians will be 5 to 15 times the number of scientists and engineers. Unfortunately, in most countries much less attention has been given to the need for technicians than the need for the professionals and as a result provisions for their education are commonly inadequate and the number electing to enter training programs falls far short of the needs. In a developing industrial economy, technicians represent the largest part of the trained personnel required.

(b) The purpose of this program is to develop in the students enrolled the knowledge, skills, attitudes, and habits required for consistent and efficient technical performance. Some of these aims are common to all kinds of technicians while some aims are specific to particular fields such as food processing, engine design and construction, road building. Among the common aims to be developed in the students are: skills in mathematical computation and measurement, skills in the use of construction tools and machines, an understanding of the major technical processes involved in the formation and fabrication of materials and in the transmission and transformation of energy, habits of completing tasks assigned, of continuous and consistent performance, of checking on the quality of one's own work, of punctuality, and attitudes conducive to technical effectiveness. The educational aims which are specific to technicians in particular fields are largely based on the more general common aims. The specific knowledge, skills, habits, and attitudes needed by technicians in particular fields can best be developed through actual work in these jobs, experience which should be coordinated with the training experience provided in the school.

(c) The educational program for the preparation of technicians builds upon the science program outlined in paragraph 2 for all children and youth, providing specialized training in the post-primary years, either as one of the chief offerings of a comprehensive secondary school or as the curriculum of special technical schools. The program should be a carefully planned period of instruction, combined with related work experience, which occupies 3 to 5 years, and normally begins with youth who are from 12 to 14 years of age. The approach to science continues the kind of participation in scientific inquiry by the student which was characteristic of the science course in the primary school. However, in the technicians' course, laboratory experiences with more use of measuring instruments are employed. The basic concepts of physics, chemistry, and biology are used by the students in their inquiries. The mathematics work extends the student's experiences in mathematical thinking and he performs more complex and precise measurements and computations. A combination laboratory and shop is also provided to enable the students to participate in making and using tools and types of apparatus, in the operation of common technical processes, and in inventing and using new technological procedures and devices. In these experiences, as well as in the activities the student has on the coordinated job, emphasis is placed on his gaining an understanding of the scientific phenomena with which he is working, skill in using the tools and instruments, and efficient work habits and attitudes.

(d) In the training of technicians in the United States, cooperative work experience has been found to increase the educational effectiveness of the program in terms of greater understanding, a higher level of skills, more efficient work habits, and a more appreciative attitude toward the importance of work. Furthermore, the use of a coordinated work experience as part of the educational program eliminates the need for the school to procure expensive machines and other equipment, farm land, health centers, and other installations required for learning the skills involved in specialized technical fields. Hence, in general, provision should be made for close cooperation with work situations for which technicians are being trained such as in industry, agriculture, and the health services. The student spends approximately half of his time during the training program in the school and half of his time on the related jobs. Commonly, the schedule in the United States is for the student to spend 3 months at school, then 3 months on the job, then 3 months at school, and so on. In some cases, however, the student alternates each day, spending half his day in school and the other half on the job. In either schedule the important point is to arrange both work and school to contribute directly to the objectives outlined above. This means that definite attention must be given to see that each student has work experiences paralleling his educational ones. The work experience helps to illuminate concepts and principles. It provides for more intensive development of skills and habits. Finally, it can be of powerful influence in creating an appreciation of the value of work in a developing economy.

4. The preparation of scientists, engineers, and other professionals requires a high quality of educational effort and it takes a longer time than that needed for the preparation of technicians, for they are expected to solve the new problems which continually arise in the process of developing a more productive and efficient economy through the use of the knowledge and methods of science.

(a) The number of these professionals who can make an important contribution to a developing country is much greater than the number who can be recruited and given the long preparation required. Furthermore, since their education is a very costly one, for every professional prepared there should be from 5 to 15 technicians trained to work with him. Since there is no immediate likelihood that the number of any of these specialized groups will be more than can be utilized effectively, the problem is to maintain the right balance between the number of professionals and of technicians and to provide educational and training opportunities for as many students as can be supported. The number of engineers needed is usually several times that of scientists. The number of mathematicians is fewer than the scientists, perhaps a third as many. Among the scientists, the agricultural, biological and health scientists are usually needed in somewhat larger numbers than the physical scientists.

(b) The purpose of this program is to develop professional competence in the students enrolled. Although the specific aims are different for engineers than for scientists and differ among the several sciences, the general common objectives include the development in the students of investigative and problem-solving skills in the sciences and technological fields, an understanding of the basic concepts and generalizations of these fields, the ability to apply these concepts and generalizations to new technological problems as they arise, and attitudes conducive to efficient performance in their professional work. The goal is to develop scientists who are continually seeking to identify pressing problems needing solution and are able to utilize their science in solving them, and to prepare engineers able to design practicable systems which aid in the solution of problems of economic development.

(c) The curriculum for the preparation of professionals builds upon the science program outlined in paragraph 2 for all children and youth. The specialized courses for scientists and engineers usually begin in the secondary school and extend into post-secondary education, either as among the chief offerings of the university or as the curriculum of special scientific or technological institutions. The curriculum should be a carefully planned period of instruction which will occupy from 6 to 10 years and will normally begin with youth who are from 12 to 14 years of age. The approach to science continues to be the kind of participation in scientific inquiry which was characteristic of the science course in the primary school. However, in the secondary school period there are more laboratory experiences using quantitive apparatus where appropriate. In the post-secondary school period, those preparing to be scientists are participating with increasing responsibility in research activities and in field studies, learning the skills of precise investigation and of problem-solving. Those preparing to be engineers are also participating with increasing responsibility in research activities and in field investigations where problems involving the design of engineering systems are encountered. These experiences are focused on the development of skills in analyzing problems, assessing the resources available, and designing systems which aid in the practical solution of the problems.

5. The preparation of teachers of science and technology is a difficult task because the teacher must have an adequate grasp of the subject he is teaching, he should exemplify the characteristics of scientific and technological activity, and understand the learning process sufficiently to be able to use the instructional resources effectively in helping students to attain the aims of the educational program.

(a) Teachers of science and technology are required for the primary schools, for the secondary schools, and for the universities and other post-secondary schools.

To staff these schools optimally, the number required would far exceed the number that can be prepared for some years to come. The impossibility of producing all the teachers needed makes it necessary to plan to use instructional procedures and devices which enable teachers to direct the learning of larger numbers of students than have commonly been assigned. For the task of the primary schools, a few well-trained scientists and mathematicians should be employed to work with primary teachers on the selection of instructional procedures, materials, and devices which can aid children in attaining the desired objectives under the guidance of teachers who have not had much training in science. In some cases, new procedures will have to be devised and new learning materials constructed, the point is that where the supply is limited, the best trained teachers and scientists can contribute most to the educational program by producing effective learning materials which can be administered by a small staff of teachers. In the training of technicians there is also a shortage of science and mathematics teachers. Hence, the same strategy should be used as in the primary schools, namely to provide learning materials which enable a competent person to guide the work of a large number of students. Since the teachers of the professionals need to exemplify the highest level of professional work in science, mathematics and engineering, their supply is doubly limited, limited by the quality and length of training required and limited by the fact that persons at this level of competence are also greatly needed as professional scientists and engineers.

(b) The purpose is to prepare teachers who are able to stimulate, guide, and direct one or more of the several programs of learning outlined in the previous paragraphs. The specific objectives and the length of the period of preparation are different for the science teacher in the primary schools, the teacher of future technicians, and the teacher of future professionals. However, there are some general common aims for all of these programs. Each should seek to develop in the students: an understanding of the nature of science and technology and their role in education, an ability to carry on scientific inquiry at the level which is appropriate for the students they will be teaching, an understanding of the concepts and generalizations which are basic to the subjects they will be teaching, an ability to plan and conduct educational programs in the subjects they will be teaching, and attitudes conducive to effective performance in their teaching work. The educational aims which are specific to the different curricula are largely based on the more general common aims. The specific knowledge, abilities, and attitudes needed by teachers of particular subjects are partly developed through actual practice teaching during post-secondary training.

(c) The educational program for the preparation of teachers builds upon the science program outlined in paragraph 2 for all children and youth. The secondary school training of teachers in science and technology is the same as that for scientists and engineers. The courses for teachers also extend into post-secondary education, either as among the offerings of the university or of the special scientific or technological institution, or as one of the courses in institutions specifically established for the education of teachers. These curricula should provide a carefully planned period of instruction which occupies from 6 to 10 years, including the years in the secondary school, and will normally begin with youth who are from 12 to 14 years of age. The approach to science continues to be the kind of participation in scientific inquiry which was characteristic of the science course in the primary school. Much of the post-secondary school training is similar to that provided for scientists and engineers, including participation in research and problem-solving activities. However, provision is also made for the students to develop some initial understanding of the role of science and technology in education and of the processes involved in learning and teaching.

(d) The preparation of a teacher involves supervised teaching experience in a school or college in order to understand the teaching and learning process more intimately, and to develop some of the initial skills needed to plan and conduct educational programs in science and technology. This experience usually begins with his assisting a competent teacher. The student then assumes increasing responsibility until he is able to play a major role in planning an educational program and can take leadership in stimulating, guiding, and directing the learning of large numbers of students. This requires close cooperation between those in charge of the program for the preparation of teachers and those who operate the schools.

6. It is now apparent that the educational tasks which must be performed in order to maintain and develop a technological economy are so great that schools and colleges must become much more effective and efficient for the necessary goals to be attained. Furthermore, the demands on education are growing greater. Some of the necessary improvements will result from the increased number of trained teachers who will be coming into the schools and colleges during the next few years. Some of the improvements will come from constructing and equipping better buildings for educational purposes. However, it seems probable that the largest part of the needed improvements must come from better planning, more careful appraisal of results and subsequent modification of plans and from the development and use of more efficient procedures and devices in learning and teaching. Much teaching now goes on without having been planned carefully in terms of the aims to be sought and without regard to the conditions required for effective learning. Most educational programs are not systematically evaluated to determine how far the objectives are actually reached, and little replanning is now carried on to use constructively what is learned from evaluation. Thus far, too, the development of new and more effective and efficient procedures and devices for learning and teaching is in its infancy. Moving pictures, television, radio, tape recordings, programmed texts, teaching machines are examples of technology now available for use in education. Efforts to employ them and develop them further must become a major concern. To increase the effectiveness of educational programs in science and technology, central services should be provided within the educational structure to help in planning and evaluating programs, to experiment with new procedures and devices for learning, and to develop and make available new ideas, instructional materials and learning devices which will increase the efficiency of educational efforts.

Principles and Policies for Developing a Comprehensive Program for Improvement of Science Education*

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1. It has now become generally recognized that every nation increasingly depends for its economic strength and sovereignty on science and technology. Increasing world populations, shortages of conventional raw materials and growing economic competition all point to further dependence on scientific discovery and technological development.

2. Not so obvious are the cultural aspects of science. Science is a part of the liberal arts and a nation's cultural strength depends at least in some measure upon its scholarship in science. Indeed, as history has shown, some cultures and nations have died because they could not or would not adapt themselves to the new age of science and technology.

3. Further, there are economic reasons why it is best for science to be considered as a cultural pursuit. Science, planned narrowly for its immediate economic value, is likely to become sterile and merely a technology by losing its scholarly creativeness. So too is education in the sciences likely to produce men trained for past and superseded technologies.

4. Technology is merely a means to an end. But the end includes at least the cultural fulfillment of man. Science, as part of this culture, serves the additional purpose of easing the material needs in a rapidly changing economic environment.

5. Science and technology also find their place in military defense and, unfortunately, offense. This places an added responsibility on our scientists to assist their fellow scholars, especially the humanists, to find the way for man to live peaceably with his neighbors using the material by-products of science for the material and cultural welfare of man living under the awful spectre of the misuse of the products of science for civilization's destruction.

6. Just as every man and every nation will profit by the material and cultural contributions of science and technology, so will they suffer by misuse of science

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*UN conference paper.

and technology. Although all men commonly will share in the application of science, good or evil, and its international language, this does not imply that there is an identical problem among nations in assuming responsibility for the education of people and for the advancement of knowledge universally. Science is created and taught by individual men of differing cultural and sociological environments and different prejudices. It would be presumptive of anyone, especially of me, to claim to know the conditions at the other end of the communication system. The impedance match can only be made by direct communication among all countries involved. Even for the best interests of advancing science, the so-called scientifically "leading" countries should not try to transmit their prejudices and unquestioned tacit assumptions to those of lesser stages of development. In the manner in which good teachers profit from questioning able students, advanced scientific nations profit by questioning younger nations.

7. In the spirit of exchanging experiences, I should like to discuss the principles we have applied in the United States in tackling the major problem of ensuring a high quality of education and training in science, mathematics, and engineering. This is especially difficult in a period when expanding school and college enrollments create a multitude of problems, and when there is an ever immediate demand for the products of science.

8. The major problem in education in the sciences is to ensure quality of the highest level. This problem is compounded by rapid increases in school populations and the immediate demands for the products of science.

(a) The great influence of science introduces my first principle for developing a comprehensive program for the strengthening of science education. Science education cannot exist apart from general education. Man, in order to be adaptable to his surroundings, must be educated in the liberal arts. This broad education, especially in the humanities, is desirable, not only as a solid foundation for all professions, but also for the understanding of science itself. Anyone who tries to understand such ideas as an imaginary number, or probability, or the product of probabilities, can acquire a better understanding of his difficulties by understanding the meaning of an ancient Greek tragedy which portrays the limitations of man's mind or failure of human reason. On the other hand, a physicist who understands boundary conditions of nature—where, for example, the physical conditions on the external boundaries of a body precisely determine the physical conditions at any point within the body—cannot escape the historical conclusion that economics or political events anywhere on their borders help determine the economic and political conditions within their own country. The first principle then is that education in the sciences is only part of the educational program to be developed.

(b) The second principle in education in the sciences, or education in general, is that we concern ourselves with the education of an individual. Thus, if we are to motivate our youth in the love of learning and toward career opportunities in science, our scholars must learn to communicate with our youth. Further creativity emanates from the individual mind. To be sure, this creation is tempered by history and by dialogue among colleagues which serves best as a stimulation to individual creativity. The most effective method of motivating our youth to science is through science itself. To do this requires that the basic principles of science, the crucial theoretical developments and the critical experiments, as well as the adventure and joy of discovery of scientific truths, must be made available to him. To do this we need teacher-scholars and scholarly subject matter to be presented to him. With increasing school populations and the rapid advancement of science, the danger is that mass production methods in education may overlook the real needs of the individual, for scientists above all must be individuals with an independent, critical, and creative intellect. This leads us to our third principle.

(c) In developing programs to educate creative scientists, scholars and creative scientists must be given a free hand in developing the scholarly substance of education. To be sure in the early stages of education, teacher training in the methods of education is essential, but it is equally important that the substance be provided by scholars. This means that the chasm which has grown between the educator and the scholar must be bridged. This means too that second-rate educators and scholars are not good enough. The problem of preparing our society to educate for the grave problems ahead requires our very best talent, our ablest scholar-teachers, and productive scholars who have the ability to think critically and effectively, who understand the basic principles of science and who know how to apply these principles creatively.

(d) The fourth principle is that the teacher is a key to excellence in education. He must be, first, carefully chosen. He must possess the characteristics of devotion to his fellow man, subject matter knowledge of his field, the art of communication of this knowledge, and the spirit of learning. He should be given the opportunity in his education to understand the basic principles of his field and an opportunity to replenish this knowledge continually when knowledge is accelerating so rapidly. He should be given frequent opportunities for intellectual refreshment, to return to the centers of intellectual creation and have some association with these creators, and be given an opportunity of keeping up to date in his discipline.

(e) In addition, he must be given the tools with which to work. The textual material which he presents to the students must emphasize basic principles and the spirit of learning, and be as nearly up to date with recent scholarly developments as possible. For this reason, our leading scholars should be encouraged to work with our leading teachers to develop scholarly substantive material for texts, and, now almost as important, films. Critical studies must also be made by our scholars to ensure that laboratory apparatus and experiments reflect modern knowledge and basic principles and avoid dull repetition of basic technologies. The student of science and technology also needs equipment, but this does not necessarily mean expensive, sophisticated equipment. Indeed, sophisticated equipment may mask the basic principles which are to be learned. It takes real skill to develop simple, inexpensive equipment which can demonstrate the basic principles of science.

9. These are the principles underlying several of the programs to be presented elsewhere in this conference. They appear to me to be universal, but their universality can be tested only by discussions with you, especially those of you who have a different cultural advantage and perspective.

Programs for Educational Development

Programs for the Improvement of Primary School Education in Science and Mathematics*

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Purposes of Primary School Science Instruction

1. Plato urged that dialectic, the highest skill of asking and answering questions, be taught to the future guardians of the ideal state—but not before they are 30. While he has supporters of the view that dialectic, and also science, should not be taught in the early years of education, none who believes in education at all has suggested waiting so long as age 30. Young children are naturally curious about the universe and their immediate environments. In early years children form their basic attitudes, patterns of thinking, and modes of behavior. It is therefore during these years that particular attention must be given to developing the attitudes and modes of inquiry that are associated with science, its processes and content.

2. One purpose of early science instruction is to teach pupils ways of asking and finding answers to questions, using the processes of science as a model. There is general consensus that we must teach the processes as well as the products of science. "Processes" is used to refer to the methods a scientist uses in his research and "products," to refer to content. Traditionally students have been taught

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*UN conference paper.

largely about the products of science and related technology. In the United States the new courses for the senior high school place much greater emphasis on the processes of science.

3. Before giving more consideration to the issue raised by processes and products, attention will be turned to a broader view of the purposes of early science instruction. Three major purposes of science instruction in the early years of school are:

(a) to ensure scientific literacy for all pupils;

(b) to develop in all pupils the disposition and ability to use scientific methods of inquiry; and,

(c) to make it possible for the average 14-year-old to study the formal structure of science.

4. Scientific literacy is difficult to define; yet, even the uninformed have a sense of what the term means. Curriculum builders must be more specific. Some definitions suggest that a scientifically literate person can successfully identify scientific fields and their interrelationships; distinguish science from technology, while understanding the dependence of technology upon science; use correctly more common scientific terms (such as, microscope, cyclotron, electron, lithosphere); identify stages of scientific inquiry; identify conditions for verification of scientific findings; and be able to give examples of how knowledge of science lends itself to modification or control of environment. Note that such a list encompasses both the products and processes of science. Other desirable behaviors could be identified as important aspects of scientific literacy and sharper delineations are needed to distinguish among possible levels of achievement intended.

5. One of the visiting lecturers from another country to the United States National Science Foundation Summer Institutes for Secondary School Teachers of Science and Mathematics in 1961 reported a conversation on his first plane trip in the United States, from Washington to Kansas. He found himself sitting beside a girl who had just finished the sixth grade (probably age 12). When she learned that he was a mathematics teacher, the girl reported that mathematics was her favorite subject and engaged him in conversation about mathematics throughout the trip of more than two hours. What amazed the visitor was not her knowledge or skill in mathematics but her strong desire to learn why a mathematical property is "true" in a given number system and upon what assumptions the proof of the property could be made. The visitor reported that, if we had been able to bring youngsters to this point of view, the study of science and mathematics for the future holds much promise for the individual and for the country. Possibly the young lady was an exceptional student but it is clear that her experience in one of the new programs of mathematics had enabled her to acquire the disposition and ability to use scientific methods of inquiry in mathematics. What the young lady demonstrated is an indication of success in meeting a principal goal of the new courses in mathematics and in science.

6. If children are to acquire a disposition and ability to use scientific methods of inquiry, their desire to investigate in the sciences must be encouraged in school by frequent experiences in scientific investigation. Plato would have seen the development of the disposition and ability to use scientific methods of inquiry as essential for the guardians of the ideal

state. Is it not in early science instruction where the best chance to achieve this goal exists?

7. What is needed as background experience for a pupil to study the formal structure of a science should be reasonably clear.

Advantages of New Course Construction

8. One of the great steps forward in the history of education in the United States has been an achievement of the past 5 years. During this period scientists and teachers in the schools at all levels of instruction have formed effective teams to produce new course materials for use in the teaching of science in the secondary schools. This approach to the improvement of education in the sciences and mathematics is now beginning to see fulfillment at the college level and in the elementary schools.

9. Some of the major benefits which have come from the availability of new sample course materials prepared by teams of scientists and teachers are:

(a) new materials have been made available to the schools, which have proved to be exciting for the pupils, stimulating for the teachers, and encouraging for the parents;

(b) a new method of curriculum development has been shown to be extremely effective;

(c) better articulation is provided among school programs at the various levels of instruction; and,

(d) teachers in the schools have a new and vital interest in the study of the most modern aspects of the scientific disciplines that they teach.

10. When scientists were enlisted for secondary school course content improvement work they, almost without exception, planned courses for the more gifted students. These students would, they hoped, become the scientists of the future. Almost by accident it has been discovered that the new courses, even though planned for the most capable students, also have proved to be the most satisfactory for the students of lesser ability. In mathematics, for example, many teachers who have been persuaded to try the new materials in classes for less gifted pupils have reported that their pupils have maintained an interest and an achievement level in mathematics that they have never known in more traditional programs. These results certainly suggest that programs planned for more capable students can become the basis of program development for all children. Many teachers are choosing to teach the new courses, with appropriate adjustments in time but little change in content, to pupils of all ability levels. Parents are unhappy if their children do not get into classes or schools offering the new courses. Teachers who have taught the new courses say they could never go back to the old courses.

11. The writing of new courses by team work of scholars in the field and teachers in the schools is a new concept in curriculum development in the United States. Teachers are beginning to be thought of as potential members of the community of scholars as new respect for teaching as a profession develops. The success of the new programs has already led to extension of this method of curriculum development not only to other levels of instruction in science, but to other fields of study. Texts on curriculum, written by professional educators, are proposing that the scholars have a responsibility for school curriculum development and also a great deal to con-

tribute. It appears likely that first efforts in other fields will also be at the secondary school level even though some critics of the new programs have deplored the fact that the work in science and mathematics started at this level, rather than at the "beginning" of formal education.

12. When new secondary school courses are produced by teams of scientists from colleges and universities and teachers in the schools, it is necessary for the teachers to become much more familiar with what is now taught in the colleges. The scientists at the college level not only have a part in deciding what will be included in new school courses, but learn a great deal about the problems of secondary school teaching. Better articulation between school and college programs necessarily follows. Now we have a Commission on College Physics and a Commission on College Biology. In mathematics a committee which prepared new college courses 10 years ago found little acceptance of their sample materials. Now that the new mathematics courses have been so well received by the secondary schools, recent work of the college committee is affecting college courses in hundreds of institutions of higher education.

13. The influence of new programs in science and mathematics on teachers and teacher education has been so great that this potential benefit will be given special attention in a later section.

14. The enthusiasm of the scientific community for extending the course content improvement efforts to the early grades is reflected in a response to an invitation to participate in early stages of the primary level work from a well known biologist of Wesleyan University. He wrote: "The project you are initiating, as you are well aware, is remarkably endowed with problems, opportunities, and responsibilities. To be able to rewrite a program of learning which can start youngsters off on intellectual insights that have represented one of the great revolutions in human thought, is at the same time humbling and tremendously stimulating. I wish your venture every success."

15. Those who embark upon the venture of stimulating the production of sample course materials for elementary school science will need humility, as Professor Hanson suggested. Work should be started in full recognition of the very great importance of the endeavor. The importance of the endeavor comes especially from the view that, if science materials of the kind that we think are appropriate can be developed, a change in the way people think may result. The challenge of developing materials of this type is, of course, equally great in all countries.

Teacher Education

16. Discussions of possibilities of bringing about a revolution in the teaching of science (including mathematics) in primary education, emphasize the difficulty of adequately preparing primary teachers to teach science. An urgent appeal is often made that first efforts be given to preparation of better science courses for these teachers and to persuasion of university scientists to teach such courses. As one who has been an active teacher-educator for over 30 years, who has participated in the preparation of innumerable committee reports, written articles for teachers' journals, spoken to hundreds of teacher groups, and taught scores of inservice courses, I am convinced that all of these efforts were of little

avail in comparison with the effect on teachers and teacher education of new courses for secondary schools which have recently been produced. I strongly urge that the teacher problem be faced head-on, but first with the preparation of materials for children to use in the classroom!

17. Perhaps the most far-reaching benefit to education in the United States that has resulted from the work on new science courses has been the change in the attitude of teachers, both preservice and inservice, toward the study of science and the concomitant change in attitude of the colleges and universities in offering appropriate courses for teachers. Even 5 years ago most science teachers in summer school studied professional education, not science. Inservice programs of schools, rarely if ever, included even so much as one lecture on science.

18. Many of our teachers are enabled to study science through the National Science Foundation institute programs. At the University of Maryland three additional courses in mathematics, along with institute courses, were offered for teachers last summer. We were afraid there might be no takers. There were more than 25 in each class, each teacher paying his own way. Five years ago such mathematics courses for teachers would have been dropped for lack of enrollment. There is every reason to expect that a similar change in the attitude of elementary teachers will result from modern courses at the elementary level both in the United States and in developing countries.

19. If a desire to learn science is created in teachers, and most teachers can have a stimulating and enjoyable experience in such study, we have a real chance to get the kind of teachers we want.

Mathematics and Science

20. Some scientists urge the teaching of science and mathematics in the primary grades as a single subject. Yet few have really thought about how this might be done, and altogether too few seem willing to tackle the problem. Efforts in the United States have already produced some exciting modern materials for mathematics study beginning at age 5. In these materials there is little direct reference to the other sciences. The authors have been captivated by the beauty (if not the utility) of mathematics. The new courses are already phenomenally successful. There, however, will be new efforts to produce a unified treatment of science and mathematics for the early grades.

21. Methods of scientific inquiry can be described in two broad categories. In one the scientist starts from knowledge that he has, clearly identifies his assumptions, and by new organization of the knowledge, builds upon it to obtain new conclusions. In the other, the scientist starts with a series of observations of a phenomenon of nature in which data are recorded and classified, and predictions are made about events which might be expected. These predictions are then tested in the laboratory to determine whether the predictions can be borne out by further observation, collection, and organization of data. Both methods of reaching new knowledge are used by scientists in all fields; both involve hard work, careful thinking, often tedious investigation, some disappointments and some successes.

22. The first is a basic point of view in mathematics. In mathematics one finds the development of a logical structure

through the process of deduction. In the other sciences there is emphasis on induction. It is this second type of inquiry which appears to hold greatest promise for elementary and junior high school science, but it holds promise only if students themselves can become involved in the inquiry. In a technological and scientific society, and in developing countries where technology and science will become of greater and greater importance, children's acquaintance and experience with induction and at least informal deduction in the primary grades can be exceedingly valuable. In the United States we are already seeing how such experiences can be provided successfully in mathematics. A similar success in science would show one way in which mathematics and science could be more closely related in the schools.

23. A still more promising key to integration of mathematics and science lies in the early introduction of quantitative ideas in science. Measurement can become an important part of science at a very early level. So long as science experiences in the primary school are largely concerned with living things, there is less place for measurement; but now we see the possibility and desirability of introducing physical concepts at least by age 6. With this change, measurement will have early prominence.

24. A handicap in the United States to the integration of science and mathematics arises from the wide acceptance of what we call "social arithmetic." More than 30 years ago, when mathematicians and other scientists had almost completely abdicated acceptance of responsibility for school programs, such topics as simple and compound interest, insurance, and stocks and bonds found an important place in arithmetic because of their so-called social significance. Socially significant topics were thought to provide motivation for the study of mathematics. Today the School Mathematics Study Group points with pride to the scientific applications in its courses (much too few in number) and to the absence of the traditional social applications. Better still, studies comparing the success on traditional tests, in which social mathematics is emphasized, of pupils who study the new mathematics with those in the "socially oriented" courses show equal achievement for the two groups of students. One major hurdle to more closely integrated science and mathematics courses has been passed.

Learning

25. Recently a young disciple of B. F. Skinner addressed a group of teachers and thrilled them with accounts of Skinner's success in teaching pigeons. One confused teacher quite indignantly, in the question period, paid tribute to the thoughtful presentation and then pointed out that she was teaching children, not pigeons. She asked: "What can you say about children?" The speaker replied that there was little to say unless the teacher could find him children who could be caged twenty-four hours a day to keep them away from parents and other questionable influences. This story emphasizes well that too seldom have learning theorists addressed teachers and too seldom have they studied children.

26. Two factors, directly related to our concern, are contributing to accelerated interest in learning research. One is the sensation produced by the Skinner teaching machines. The other is the determination to develop new programs in sci-

ence and mathematics for the schools. The use of programed materials, whether with or without teaching machines, provides a way to control variables in learning studies and especially to explore the role of structure in learning. The emphasis on structure in the new science programs and the respectability for scientists to participate in the planning and writing of the new programs make it much more attractive for psychologists to study how children learn.

27. Just as he has deplored the fact that development of secondary school programs preceded development of elementary programs, the educator also has deplored the fact that new programs in science are followed by research in learning rather than preceded by such research. This possibly is cause for regret. But the regret need not be of long duration if learning research can now be carried out concurrently with the development of new programs. The job of preparing new science programs for the primary grades becomes a job for team effort by teachers, psychologists, and scientists from the other disciplines.

28. Studies of how children learn mathematics and science most appropriately have a place in the development of new programs for primary school children. In developing countries, along with tryout of new sequences, questions related to cognition, integration and repetition, verbal generalizations, determination of what children can learn, and the relation between ability and speed of learning, should receive specific attention. Scientists and teachers are asking questions, and psychologists are beginning to give assistance in formulating these questions so that they can be investigated.

29. One question seems of special importance. Can all children learn mathematics, or are there blocks in learning mathematics like there are for some children in learning music (for example, physical difficulties in hearing)? The answer is almost certainly that all normal children can learn mathematics, and hence, science. Psychologists can assist us in finding convincing scientific evidence for this conclusion. Some evidence is already suggested by controlled research utilizing programed instruction and by recognition of the importance of structure in new science programs. Developing countries should take as a goal in education the removal of the social acceptance still widely accorded to those who feel comfortable in saying "I could never learn the multiplication tables!"

Technological Teaching Aids

30. The promise of programed instruction and teaching machines in relation to new science programs has been noted. Teaching machines are only one of many new technological aids, unfairly called teacher substitutes, which will have an effect on new science programs. Another is the 8-millimeter projection camera, recently developed by British technologists. Other papers in this conference will give attention to many more. The Physical Science Study Committee (PSSC) has done the best job in the United States of producing "a package" of teaching materials for a new course: student text, teacher commentary, supplementary study materials for students and teachers, inexpensive laboratory equipment, films and slides. The PSSC plan is to be highly recommended to developing countries.

A Content-Process Chart

31. To a remarkable extent there is now universal acceptance of the point of view that science instruction before age 14 must be predisciplinary. There is also consensus that no single program, or sequence, for use in all school systems is advisable. Note that this conclusion is contrary to practice in mathematics. It is generally held that subject matter and pace can best be chosen to fit existing situations within each school because of geographical and economic factors, competence of staff, and other considerations.

32. There has been less agreement on the relative emphasis on processes and products (content) but frequent suggestions that probably, until age 9, the primary goal must be to teach the processes and to plan the course of study with this goal as the major criterion in determining content; namely, to choose the content which would be most appropriate in providing experience with a given process goal. Again, there appears to be wide acceptance of the point of view that laboratory experiences would be an essential and overriding element of all science instruction before the high school.

33. In early exploration of possibilities for development of a science sequence for grades K through 9 (usually the pupils are ages 6 through 14) in the recently undertaken AAAS study of elementary science instruction, it was proposed that a content-process chart be prepared. The chart could be used as an instrument for identifying gaps in new materials available or in preparation, and for giving some direction to work which needs to be undertaken. Note that the chart gives equal place, in title anyway, to content and processes. The chart would in no way be intended to hamper the free development of ideas by the individual scientist or teams of scientists and teachers. The chart would provide a framework for a structure of science experiences over a 10-year period, into which even the most bold experiments could be fitted. The chart could be helpful as the work progresses and later when schools organize their now new programs, making use of a large number of experimental studies. Many such charts of course have been prepared for existing programs, but not by scientist-teacher teams, and not from the viewpoint of modern science.

34. A further elaboration of the content-process chart suggested that the curriculum builder think in terms of a truncated trigonal pyramid in which one face represents the processes of inquiry, another the disciplines (physics, botany, and so on), and the third, broad conceptual themes of science. Such a pyramid, at the moment, is promising; yet, one recognizes that its building can be done only by the hands and minds of many men, as in Egypt 5000 years ago, and *only* if an Archimedes, a da Vinci, a Jefferson, a Darwin, and a Gauss are consultant architects. Those with a more psychological turn of mind even propose that the truncated pyramid become pentagonal by adding two more dimensions, the child and the teacher. If so, a Grassman and a Veronese will have to be added to the consultant list.

35. In sober moments one also knows that architects with the qualifications proposed are no doubt among us and in some cases within a single country. They will be easier to identify on an international basis, however, and the magnitude of the job suggests an international approach. Indeed, such an approach is

already underway and most surely will be stimulated by this conference.

36. Just as there are those among my colleagues who firmly believe that efforts to prepare a statement of purposes and objectives of science instruction in the early grades will be wasted effort, and perhaps even harmful, there are those who believe that an attempt to prepare such a content-process chart will bear no good fruit. I disagree and in disagreeing urge that developing countries give early attention to the building of such a guiding chart, which would be highly useful even as it is frequently revised and extended. An exciting phenomenon of man, our society, and our times is the realization that the resolution of the content-process enigma is as important for developing countries as for countries of high-level scientific and technological achievement and for precisely the same reasons.

The Challenge

37. What makes a difference between action and passivity is a feeling that things might get better if something is done about present conditions, as contrasted with a feeling that things are likely to stay about as they are or probably get worse. A scientifically literate person recognizes that acquisition of an understanding of our environment through science enables him, with the help of others, to modify or control environment through technology. Perhaps the most compelling reason of all for new programs in science is that the study of science gives hope and provides a way of action in which hope can be realized.

38. One view of man holds that great responses exist inside man and that they need only to be invoked to become manifest. It is the privilege of anyone in a position of leadership to appeal to the most towering possibilities. It is my thesis that the development of proper programs in science in the primary years offers one exceedingly promising way to invoke these responses. Early science study gives promise of progress in science and technology, promise for people to learn how to ask and answer questions properly—and, for better understanding of man and among men. The difficulties are enormous, but the rewards are commensurate—probably survival and approach to an ideal state.

Program for the Improvement of Secondary School Education in Science and Mathematics*

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Introduction

1. The rapid advance of science and technology in recent years has brought to all nations a new appreciation of the importance of high quality education in the sciences. Achieving this quality in science education in any country is not an easy task and cannot, of course, be done overnight. An important step in the general improvement effort is to modernize science and mathematics education at the secondary school level. Attacking the problem at this level can profoundly influence developments at other educational levels. Further, it is a level especially amenable to development.

2. Although approaches to the improvement effort may vary from country to country, three fundamental problems which confront all those who seek to develop a more adequate system of pre-university science and mathematics instruction are: (a) the need for improvement of the teaching staff; (b) the need for improvement in substantive course content—to assure scientific validity, but in a format which more effectively encourages students to learn; and (c) the need for improvement in physical facilities—classrooms and instructional equipment. In addition to an adequate amount of time and money, a venture of this order of magnitude requires the efforts of many interested and dedicated people. A great deal of progress can be made in a relatively short period of time if programs which fill the basic requirements for improvement are vigorously pursued.

3. That each country has its own special problems, attitudes, and philosophies with respect to education is well known. Also, it is realized that these factors have an intimate relationship with the ways in which education in the sciences can be improved in a given country. A discussion of experiences of the United States in improving its instruction in science and mathematics at the secondary school level may provide some helpful suggestions to other countries with similar aims.

4. The general philosophy of the American people concerning education is well expressed in a quotation by a former President of the United States:

> "Education best fulfills its high purpose when responsibility for education is kept close to the people it serves—

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*UN conference paper.

> when it is rooted in the home, nurtured in the community, and sustained by a rich variety of public, private, and individual resources. The bond linking home and school and community—the responsiveness of each to the needs of the others—is a precious asset of American education."(1)

Hence the control of education in the United States is vested primarily in the local community; the central government's responsibility is primarily that of providing assistance where and when needed, but assistance without usurping control. As scientific advances pointed up the need for more and better-trained scientists and engineers, many individuals felt that the status of science and mathematics education in the secondary schools of the country should be reassessed. Studies revealed that there was a great need for improving education in the sciences at the pre-university level.

5. Primary responsibility for secondary-school education in the United States rests with the individual States; however, the Federal Government has responsibility for assisting in educational efforts which concern the Nation as a whole. Consequently, the Federal Government has become increasingly active in promoting education in the sciences, and during the past 10 years substantial improvement in science and mathematics education has been achieved with its massive support. Although the specific approaches employed in the United States are not necessarily applicable to the educational problems of other countries, many countries have expressed interest in them, and have adopted and adapted some of them.

6. The federally supported programs designed to assist in this improvement effort in the United States have been administered through two agencies: the National Science Foundation (an independent agency of the Federal Government) and the U.S. Office of Education (a component of the U.S. Department of Health, Education and Welfare). The National Science Foundation's programs, developed in cooperation with the scientists themselves, are aimed at improving the subject-matter competence of teachers and the course content and instructional materials used in the Nation's classrooms. These programs deal exclusively with the sciences and operate by the Foundation's granting of financial support to projects which, in most cases, are designed and executed by the science, mathematics or engineering faculties of colleges and universities or by professionals in these fields working through their respective scientific societies. The programs administered by the U.S. Office of Education are designed to strengthen education in general through State and local school systems. In connection with the improvement of instruction in science and mathematics at the secondary-school level, the U.S. Office of Education administers a large-scale program designed to assure an adequate supply of instructional equipment in science classrooms.

Teacher Training Activities

7. In the United States, as in many other countries, the improvement of secondary school education in science and mathematics is an important national goal. Consequently, the National Science Foundation nearly a decade ago began to develop new and appropriate mechanisms for achieving this goal. Among the more important mechanisms that have been developed are the training programs for "in-service" teachers. Known as Summer Institutes, Academic Year Institutes, In-

Service Institutes, and Research Participation for High School Teachers, these programs have met an important need and have become very much in demand throughout the United States.

8. "Summer Institutes", inaugurated by the Foundation on an experimental basis in 1953, have proved to be a most effective mechanism for improving the subject-matter competence of teachers. These especially designed summer programs or seminars provide teachers the opportunity to review basic subject matter and to become better acquainted with recent discoveries in the subjects they teach. Because Summer Institutes have been so successful, their number has grown steadily. Beginning with two Summer Institutes for teachers of science and mathematics in 1953, the National Science Foundation supported institutes of this type increased to 421 in 1962. The number of secondary school teachers who attended such institutes during the summer of 1962 reached a record high of 20,469.

9. The effectiveness of the Summer Institutes can be attributed to three basic facts: (a) the institutes provide courses that are specifically suited to the needs of teachers; (b) the institutes are conducted in a manner designed to result in maximum learning; and (c) the teachers who attend receive financial support which enables them to devote full time to the institute training.

10. All institute programs have two primary objectives: (a) to improve the teacher's mastery of the subjects they teach and (b) to increase their ability to motivate students to consider careers in science and related areas. Courses offered in the institutes stress the subject matter of science and mathematics rather than methods of teaching, although the latter may receive attention. Usually the courses are aimed toward comprehension of fundamental generalizations and principles rather than mere recitation of descriptive material. This rigorous instruction in fundamentals has helped to develop among the teachers a scholarly attitude which is being reflected in their classrooms and shared by their students.

11. Institutes vary in the type of instruction they offer, but all use the group training approach. Some are designed for teachers who have weak backgrounds in subject matter, either because their general backgrounds are inadequate or out-of-date, or because they have been assigned to teach courses in a subject other than their specialty. Other institutes offer instruction at an appropriately advanced level for teachers who already have relatively good backgrounds in subject matter, but who desire additional training that will make their teaching more stimulating and will truly reflect the latest scientific knowledge. Experience with Foundation-supported institutes has indicated that the selection of homogeneous groups of participants—teachers with similar educational backgrounds—is highly desirable. Specifically suitable courses can be designed and the courses can be taught more effectively, and at an appropriate pace, when the participants have comparable backgrounds. Also, it has been found that participants with similar backgrounds but who come from a wide geographic area are likely to learn more from each other than participants whose subject-matter backgrounds differ or who come from a single geographic region.

12. Usually teachers who have weak backgrounds are likely to benefit more from programs which emphasize coherent, continuous course work—while for

the teachers with strong backgrounds, a relatively greater emphasis on distinguished visiting lecturers is frequently appropriate. In all institutes, experience has shown that considerable time for discussions should be allowed. Course work offered by the institutes varies in type. Some Summer Institutes offer work in several fields of science and permit each participant to choose his own combination of courses. Other institutes offer work in a single field, which in some cases might be as elementary as "Fundamental Principles of Chemistry", and in other instances might be as specialized as "Recent Advance in Thermodynamics". If an institute program is confined to a single subject-matter area and level, very desirable ***esprit de corps*** quickly develops.

13. The benefits from group interaction constitute one of the principal advantages of institutes over ordinary summer schools. It has been found that participants gain from each other, through informal discussions outside the classroom among themselves. Indeed, the benefits derived from the participants' exchange of stimulating ideas and their teaching experiences are sometimes reported to be as great as the benefits received from the courses and lectures. Usually participants are housed in an area especially reserved for the institute; arrangements are made for the group to eat together at least once each day, and lounges where impromptu discussions can occur at any time are provided. Also, activities such as coffee breaks, field trips, occasional evening lectures suitable for families, and occasional picnics have been successful in serving to foster group spirit and promote discussions among the participants.

14. The length of time an institute is in session will (typically) be from 6 to 8 weeks. (This means that most teachers still have some time for a brief vacation period before returning to their teaching duties in the autumn.) The institutes are conducted at various colleges and universities throughout the country with funds provided by the National Science Foundation. In addition to funds to pay for operating costs, the Foundation's grants include support for the participating teachers in the form of stipends and travel and dependency allowances.

15. Allowances for participants are intended to cover the normal expenses involved in attending the institutes. In addition to a travel allowance for one round trip from home to institute, each participant receives a weekly basic stipend and an allowance for dependents. The stipend and dependency allowances are set at a level high enough so that a teacher can afford to forego earnings he might otherwise obtain through summer work outside his profession, although the financial emoluments associated with institute attendance do not ordinarily serve to replace all of the income the teacher would have derived from summer employment. Most (sometimes all) of his stipend is needed for expenses at the institute—usually room and board, etc. He does not have to pay tuition or fees since the National Science Foundation pays the operating costs of the institute.

16. The colleges and universities which conduct Summer Institutes assume full responsibility for the planning and administration of such programs. Plans or "proposals" for institutes are submitted to the National Science Foundation by institutions and are evaluated by panels of non-governmental consultants—scientists and educators—who are in no sense employees of the Foundation. For those plans which are judged to be most meri-

torious and most likely to offer the greatest educational benefits to the teacher-participants, the Foundation provides the necessary financial support.

17. Although first conceived as a remedial, temporary, and expedient mechanism for improving science education in secondary schools, the summer institutes mechanism seems now to be regarded as a more or less permanent part of the educational scene in the United States. It has come to be recognized that, even if all teachers could be brought to adequate subject-matter mastery for the present, their knowledge would be too much out-of-date within a few years. Also, there is not only the problem of correcting subject-matter deficiencies of the present teachers; many new teachers—fresh from teacher-training programs—are found to be inadequately prepared. New and better approaches to the training of science teachers-to-be is one of our most important unsolved problems.

18. The program called "Research Participation for High School Teachers" is another type of National Science Foundation activity which has been very helpful in improving the science teacher's classroom instruction. It offers training in scientific research and is intended for teachers with better-than-average preparation in science. Participants are given the opportunity to gain research experience with competent investigators at colleges, universities, and non-profit research organizations. Not only is the teacher's understanding of science and the scientific method increased through such experience, but, in some cases, teachers are able to carry out research which may lead to an advanced degree. This program, too, is designed as a summer activity; however, provisions are made for the support of a limited number of participants to continue their research (part-time) at their home institution during the academic year.

19. Teachers enrolled in research participation programs receive the same stipend, travel, and dependency allowances as do participants in the Summer Institutes. Research opportunities are offered in a variety of disciplines in the mathematical, biological, physical and engineering sciences, and in psychology. A typical program is of 8 to 10 weeks' duration.

20. Academic Year Institutes and In-Service Institutes, similar in purpose to Summer Institutes, deserve mention as extremely valuable Foundation-supported programs for teacher training. In the Academic Year Institutes, secondary school teachers are given the opportunity to study intensively an appropriate sequence of courses in the subject matter of their disciplines; such study is pursued on a full-time basis for 9 to 12 months. Stipends and allowances are provided to the participants. The In-Service Institutes, in contrast, offer instruction in science and mathematics on a part-time basis during the academic year at colleges or universities, or at off-campus centers, so that teachers may attend while still teaching full-time in their schools. Classes are held on Saturdays or during after school hours. Teachers participating in In-Service Institutes receive no stipends, but do receive modest travel and book allowances. As in all the institute programs, the Foundation's grants to sponsoring institutions cover the participant and operational costs of the In-Service programs.

Course Content Improvement

21. In addition to the major task of improving the subject matter competence of its teachers, the United States was—and in large measure currently is—faced with the equally important task of developing courses of study in science and mathematics for use in the Nation's schools which reflect in an adequate way modern advances in science. For some time it had been recognized that courses in these subjects had, in general, lagged a generation or more behind the state of knowledge in a given field. Patterns of reform in course materials began to emerge in the early and middle 1950's. About that time many scientists, mathematicians, and engineers in universities became gravely concerned about inadequacies in the preparation of entering college students.

22. Realizing that a major effort was needed in this area, the President's Science Advisory Committee in 1959 clearly pointed out what was required of the country's leading scientists:

> "This is not a task from which the scientists themselves can stand aside. It requires the attention of the most able scholars in the various fields; men who have an encompassing view of their subjects; who know their subtleties and who can judge the emphasis which can sensibly be given each aspect." (2)

A number of such scholars had participated in early experimental projects for curriculum reform and their significant contributions to the course improvement effort were immediately recognized by all concerned.

23. Through grants made by the National Science Foundation in 1956, the first of a number of major federally supported projects for course content improvement in the sciences got under way. These projects represent the highest order of scholarship in the development of curricula, courses, and instructional materials that reflect contemporary scientific knowledge and points of view. Plans for such projects come into being when scientists of high professional stature and teachers of recognized competence and experience determine that an urgent need for improved subject matter exists in a particular field—and these individuals propose the action to be taken. Projects for course content improvement are selected for support solely on the basis of their merit, as are all projects and programs which are funded by the National Science Foundation. Grants are made to the institutions of higher learning or other organizations with which the project directors (university scientists) are associated in the conduct of such projects. Emphasis is placed on subject matter rather than pedagogy in these course improvement efforts. However, teachers take part in the initial writing and in the classroom trials of the preliminary versions of new courses to insure that the materials developed will be pedagogically sound.

24. Large-scale projects concerned with physics, mathematics, chemistry, and biology courses for secondary school students were the first to receive the attention and support of the Foundation. New course materials in these subjects areas were developed by study groups and then tested in various high schools in various regions of the country. Tests of materials must be alternated with revisions until the materials meet the requirements of scien-

tists, teachers, and students. Materials thus developed include textbooks, equipment designed for learning through personal experience in the laboratory, and teaching aids (such as educational films and television presentations), sourcebooks and guidebooks for teachers, paperback books on supplementary topics for teachers or students and correlated combinations of all.

25. A contribution of great importance to the improvement of science education in general was made by the work of the Physical Science Study Committee (PSSC)—the first major project for improvement of course content at the secondary school level to receive support from the United States Government. In 1956 this committee, made up of some of the most outstanding physicists and teachers in the United States, set out on the task of designing a new physics course for high school students. Now essentially completed, this major effort required several million dollars from private foundations and the National Science Foundation, and the arduous labors of several hundred people from universities and colleges, secondary schools, and research laboratories. Early versions of the materials developed by this large team were subjected to searching trials in schools. The PSSC-developed books, films, and apparatus are now available through commercial distributors to any school in the United States that desires them. During the 1961–1962 school year about a fifth of all students studying physics in United States schools were taking the new course, and instruction for many others has been influenced in some degree by the new materials.

26. Besides illustrating the results of a method of reconstructing science curricula through collaborative efforts of research scholars and teaching scholars, the work of the Physical Science Study Committee encouraged scientists and scholars in other fields to undertake similar activities in their specialties. Interest in the Physical Science Study Committee project has also been expressed by scientists in other countries.

27. In the field of mathematics a group known as the School Mathematics Study Group, aided by grants from the National Science Foundation, began course development operations in the summer of 1958. Since then, this group has done a tremendous amount of work in developing sample courses, textbooks, commentaries for teachers, and associated materials for grades 4 through 12. Definitive versions of the model materials for grades 7 through 12 are now available to the schools that wish to use them. Further work is under way on materials for lower grades, on an alternative 10th grade geometry course, on self-study books for teachers, on experimentation on programmed presentations, and on a long-term study of the effects of the various new approaches to school mathematics.

28. The status of chemistry courses in the secondary schools of the United States was perhaps somewhat less serious than in other scientific fields. Over the years university chemists have attempted to help schools through such means as journals and review courses for teachers. Nevertheless, leading chemists came to realize that most school courses failed to give adequate attention to fundamental understanding of chemical processes, despite the great strides the science itself has made in the last two decades. The question of the roles of secondary-school and beginning college courses in

chemistry was soon explored. This inquiry led to the idea of designing a high-school chemistry course that would stress basic principles with chemical bonding as a central theme. With financial assistance from the National Science Foundation, an effort known as the Chemical Bond Approach Project was carried forward. A definitive edition of a chemistry textbook produced by this project is expected to be available for use in high schools by the fall of 1963.

29. Since diversity has always been a highly valued hallmark of American education, it was no surprise when other chemists advocated a high-school course somewhat different from that proposed by the Chemical Bond Approach Project. Thus, another important contribution in this field is being made by an effort known as the Chemical Education Materials Study. This group is devising a course with special emphasis on chemistry as an experimental science. In addition to a basic textbook, a laboratory guide, and teacher's guide, the group is preparing films, supplementary readings, charts, and other learning aids. By the fall of 1963 a definitive edition of the textbook and the laboratory guide are expected to be ready for school use.

30. Biology, too, has received the attention of first-rate scientists and teachers who became interested in the problem of creating better science courses for secondary school students. In 1959 an effort known as the Biological Sciences Curriculum Study undertook the development of modern course materials for the study of biology. With the aid of National Science Foundation grants, this group has made considerable progress in producing new materials. The first version of experimental materials was tested during the 1960–61 school year. During the following year some 400 schools were testing revised versions. Eventually at least three different biology courses suitable for the secondary school level will be completed under the Biological Sciences Curriculum Study project. By 1963 this group expects to have commercial versions ready for use in any school desiring to utilize these new materials.

31. Certain common elements in the objectives and the operation of the secondary-school study groups deserve mention. Each project has aimed at a course in which the major developments of the field are presented in logical sequence. Technological and purely descriptive aspects have been de-emphasized, and major attention has been given to basic concepts and principles. Special stress has been laid on the laboratory part of the course; the objective has been to replace routine "cookbook" procedures with an approach in which the student will develop a genuine feeling for the nature of scientific inquiry and discovery. In some cases, parts of a course are taught largely through laboratory experience.

32. In all fields, students and teachers in the trial schools have responded with enthusiasm to the various new approaches. The high level of student achievement has demonstrated that students are willing and eager to delve into content which a few years ago many teachers would have considered far too difficult.

33. Somewhat to the surprise of scientists and educators in the United States, these course-content improvement efforts undertaken to meet American needs have turned out to be of great interest to coun-

tries in every section of the world. Because it was developed first, the physics course produced by the Physical Science Study Committee has attracted special attention. Seminars, conferences, and other meetings on this course have been conducted in Great Britain, Austria, Scandinavia, Israel, Italy, Brazil, Japan, Pakistan, and India. Translations and adaptations are currently being prepared in several countries.

34. A recent experience in Nigeria further illustrates the interest of other countries in these new course materials. During the past fall, high school students in Nigeria shared with their contemporaries in the United States the benefits of the modern concepts presented in new curriculums in mathematics, physics, and chemistry which are now widely taught in United States secondary schools. In preparation for teaching these courses, 56 Nigerian mathematics and science teachers received instruction for about 6 weeks during the past summer from American professors and teachers at University College, Ibadan, Nigeria.

Scientific Instructional Equipment

35. Well-trained teachers and modern courses contribute substantially to better science instruction in the schools, but another major need must be met in the total improvement effort—the need for laboratory space and scientific equipment. Good science teaching demands scientific instructional equipment of the right kind and in the right amount. When the United States looked into this situation, it found that a critical need for improvement in these areas existed and that financial assistance from the Federal Government would be of great benefit in correcting the deficiencies in physical facilities. Consequently, a program was established in 1958 under the aegis of the U.S. Office of Education to provide for Federal grants to State educational agencies to aid local educational agencies to acquire laboratory or other special equipment for science and mathematics teaching in public schools. Also to be included in these grants were funds for minor remodeling of laboratory or other space to be used for such equipment. Under this program States or local school systems are required to match the Federal funds on a dollar-for-dollar basis.

36. With the aid of Federal funds provided by this program, schools have been able to acquire, for example, resource materials and equipment in mathematics such as demonstration models, resource books, periodicals, filmstrips, films, and other materials for enriching instruction in mathematics. Science instruction has been improved by the acquisition of equipment such as microscopes and portable demonstration laboratories.

Conclusion

37. An abundant amount of evidence accumulated over the past several years clearly indicates that the programs just described have aided materially in raising the qualitative level of science and mathematics instruction at the pre-university level in the United States. Some of this evidence has been produced through research studies carried out by trained investigators, but a considerable portion also comes from teachers and students who have experienced direct benefits from the institute training, course-content im-

provement projects, or the scientific equipment program. There is no question that these activities which have been initiated and carried forward by the National Science Foundation and the U.S. Office of Education have contributed significantly to the improvement of education in the sciences in the United States. It is quite possible that other countries facing similar problems would find such programs, or modifications of them, effective in improving the quality of secondary-school science and mathematics education in their schools.

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The Requirements for Major Curriculum Revision*

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1. In this paper, "curriculum revision" is intended to signify the entire process of the preparation of educational materials for use in the formal school system, or in direct association with the formal school system. It is thus an inclusive term, and in the context of this paper should be distinguished from the more limited activity in which general curricular directives are set forth and their implementation left to others.

2. Over the past 6 years, major curriculum revisions have been undertaken in the United States over a wide range of subjects. Early activities were restricted to mathematics and the natural sciences, but more recently revisions have been extended to the fields of modern languages, including English.

3. The purposes of all these activities are much the same. They reflect, in the first place, dissatistaction with the gulf that has been permitted to open between the professional scholar or research scientist, on the one hand, and the schoolroom on the other.

4. This general dissatisfaction has been reinforced by a growing awareness that the capacity of children to learn has commonly been grievously underestimated. Mathematicians particularly have discovered that children by the age of 10 years or even less can master extremely subtle concepts, if those concepts are properly presented to them. Investigations over the past 10 years have led one psychologist to propose that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development." (1) Even if this statement is broadly qualified, it remains difficult to presume that the gulf between the professional practitioner and the general student is a necessary consequence of the student's incapacity or unreadiness. If any charge of incapacity or unreadiness is to be laid, it must now be upon the professional scholar himself, who has been either incapable of presenting his disci-

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pline in an appropriate manner or unwilling to divert himself from his specialized activities to make the requisite effort.

5. The arousal of fundamental interest in the content of elementary and secondary education is a development of profound significance. Curriculum revision has attracted the participation of professional scholars whose leadership made the recent massive efforts effective. The first such revision to be carried out as a major program on a national scale was that of the Physical Science Study Committee, which began in 1956 and entered the American school system as a complete 1-year physics course in 1960. Most later revisions have been patterned to some degree upon that carried out by the Committee. Considerations set forth in this paper reflect the close association of its authors with the Physical Science Study Committee program, and consequently are likely to be drawn from the Committee's experience; they should be taken as applicable to the entire range of curriculum revision to the extent that they are general considerations arising out of general problems.

6. At least four distinct components can be distinguished in a program of curriculum revision: (a) The process of determining the precise boundaries of the educational unit that will be treated; (b) the process of identifying the subject-matter which is to be dealt with within that educational unit; (c) the embodiment of that subject-matter in material form, as text, laboratory or classroom materials, and other learning aids; and (d) the preparation of teachers in the new subject-matter and in the use of the materials. Of these four components, the first is likely to precede the rest; the determination of subject-matter, its embodiment, and the preparation of teachers must however be carried on to a large degree simultaneously.

The Educational Unit

7. In an ideal sense, the educational process is a continuum, no portion of which should be treated in isolation from the rest. Yet, such an isolation must be arbitrarily imposed before curriculum revision may be undertaken. The project must be reduced to manageable size if it is to be broached with any confidence and completed in any reasonable period of time. Revision of "education" is not a goal that may be realized directly: rather, it must be approached in terms of revision of mathematics in the early grades, or of English in the secondary school, or some such practical unit.

8. In the United States, with its wide variety of school systems, each of which is in some degree independent of the others, there is also a compulsion to work in small units. The Physical Science Study Committee, as its name implies, would have preferred to create a 2-year course in physics and chemistry rather than the 1-year course in physics that it finally produced. Yet, it was necessary to recognize that most American secondary schools, as they are now constituted, would not find it possible to fit a 2-year course into their structures. The decision to restrict the revision to physics was made reluctantly, but in practical terms it was the only decision open to the Committee.

9. The School Mathematics Study Group chose to embark on a revision of mathematics curriculum over a 6-year range, which has since been extended to 9 years. This was possible only because the Group was able to retain the

general structure of mathematics curriculum and effect its changes within that structure. Thus, the School Mathematics Study Group became a group of related programs, each of which worked within an existing structure, rather than a single extensive program of curriculum revision.

10. It may be protested that this unitary approach leads to a lack of coherence, or at least to a roughness at the seams where units meet. This can scarcely be denied. But with conventional curricula, in the United States at least, the incoherence already exists and, indeed, defies attempts to remedy it. The task of joining a 1-year physics course to a 1-year chemistry course will surely be simpler when the courses themselves reflect the outlooks of the physicist and chemist, for in those outlooks the coherence is known to exist.

The Determination of Subject-Matter

11. Two questions must be answered in the course of determining the subject-matter that will constitute the unit under consideration. First, what is it desired that the student learn from the unit? Second, what selection of material and what ordering of that material will make it most probable that he will indeed learn?

12. There is never a unique answer to the first of these questions. Turning again to physics, one might wish to provide the student with an intimate knowledge of modern technology, or with an acquaintance with the manner in which physics has grown. During the early days of the Physical Science Study Committee, both of these were entered as possibilities and were warmly debated; if either had carried the day, the Committee physics course would be quite different from the course as it now exists. In fact, it was decided instead that the course would be directed toward familiarizing the student with two central notions of modern physics: the wave-particle duality and the modern concept of the atom. Behind this decision was the view that these two notions lay at the heart of the modern physicist's outlook upon his universe, and that it was this outlook that the course should convey.

13. This answer set boundaries upon the answer to the question of selecting and ordering. If a one-year course was to deal intelligibly with the wave-particle duality and nature of the atom, much that has been conventionally taught as physics would have to be ignored or skimped. Physics is too rich to be taught in its entirety in a single year; the criteria of selection would have to identify those portions of physics which contributed to the elucidation of the wave-particle duality and the nature of the atom.

14. As a consequence, the Physical Science Study Committee course contains little about sound, or electric circuitry, or relativity. They are omitted, not because they are devoid of interest, but because they are not central to the theme. Instead, the course proceeds through optics and the behavior of light to the kinematics of waves, then to Newtonian dynamics, electric forces and, finally, the atom. All this is told as a continued story, in which each chapter is firmly bound to its predecessor and leads to its successor.

15. Considerations of this sort are common to all curricular revisions. In every academic discipline, scholarship over the last century has reaped rewards so rich that even the most eminent scholars can-

not hope to master their subjects in anything approaching their entirety. No student, during his 12 years prior to college, is going to "learn" English literature; at best, he will become reasonably familiar with some small part of it. The task of the reviser is to see that what he learns is appropriate, and that through what he has learned he will be able to grasp the significance of the discipline as a whole.

16. The Physical Science Study Committee, and secondary-school revisions in general, have also the special problem of dealing with students who in all likelihood will never again engage in formal study of the subjects they encounter in secondary school; the view of those subjects which they gain in secondary school will be the view they carry through life. Clearly this must affect the general decision on subject matter. A course in mathematics for the first grade, where study is clearly preliminary to further study, might well reach an entirely different kind of conclusion. Yet, the process of decision is the same: what would you have the student learn? how is he to learn it? If the subject is French, will he be expected to speak the language or to read it? Will he study French further? Is he to comprehend "Le Figaro" or Villon—or "Le Canard Enchaine"? There is no certain answer to any of these questions; they are matters for decision.

17. Nor can it be assumed that the selection and ordering of subject-matter will flow unerringly from the decision on purpose. The test of a curriculum lies in the classroom. However ingenious the selection and ordering, they must prove their worth in practice. It must be demonstrated that the student understands and, indeed, employs those elements of the professional outlook which have been presented to him. Classroom experimentation with materials, and the provision of a system by means of which classroom experience can be evaluated and fed back into the process of revision, are basic requirements of any major program of curriculum revision. Without such a feedback system, the program wanders blindly into unknown territory, and is likely to end with a curriculum which in practice accomplishes no part of what it intended.

Production of Materials

18. Materials, in the sense in which the word is used here, may be defined as anything which may be brought into the classroom to aid in the learning process. In the first instance it is the textbook, and for the foreseeable future the printed text is likely to remain the prime learning aid. But it is by no means the only learning aid. In most science courses, the laboratory is central to the learning process, and learning aids must necessarily include laboratory equipment, laboratory manuals and guides, and the carefully designed experiment. In almost all subjects the learning process can be stimulated by motion picture films, projected directly or by means of television. Live television may also be expected to play an ever-increasing part. Programmed self-instruction may in time contribute substantially. Tape recorders are particularly significant in language teaching. Nor should the importance of secondary materials, such as posters, slides, charts, and corridor displays be ignored.

19. Two other learning aids might be singled out for attention here. The first of these is collateral reading matter. The provision of such reading matter becomes almost an inescapable obligation of the

major curriculum revision, arising both out of its mode of operation and its purposes. The process of elimination which takes place in organizing the course implies that gaps will be left. For some students, these gaps may represent the very areas of the subject in which personal enthusiasms have been engendered, and it is only reasonable that the student be enabled to fill such gaps by his own efforts and on his own time. Collateral reading, prepared for the purpose, can help in this task.

20. Another major learning aid is the examination. It is not always thought of as a learning aid, but it is in fact one of the most effective. Programmed self-instruction, in at least some of its forms, is a recent recognition that the process of a monitored self-examination is a powerful learning tool.

21. The production of any of these materials requires the services of technicians: the writer, editor, typesetter, and publisher; the producer, director, cameraman, and film editor; the designer and manufacturer of laboratory equipment. It is in the linkage between scholar and technician that the curriculum revision is most likely to fail.

22. The central fact is that responsibility for the finished material can neither be assigned to the technician nor shared with him. It must lie with the scholar, and he must insist that it lie with him at all times. The writer, editor, typesetter, and publisher must serve him, and not he them. If he is making a film, he must be prepared to act to some degree as his own producer, his own director, his own cameraman, and his own film editor. This is a commitment he must make as part of any commitment to labor in the field of curriculum revision.

23. It is clear why this must be so. There will always be a tension between subject matter and the form of its embodiment. The best textbook, from the viewpoint of the teacher, is not necessarily the best textbook from the point of view of the professional typographer or the professional bookbinder. The criteria of teaching or of scholarship are not the criteria of film-making. These tensions must be resolved, and it is the responsibility of the scholar and the teacher to see that they are in every instance resolved in favor of scholarship and pedagogy.

24. This is by no means easy to accomplish. To make good films, for example, requires the services of a good director. A good director will have ideas of his own, and they will be ideas that respond to the imperatives of his own profession. But these are not the imperatives of scholarship or of pedagogy, and it will frequently happen that the scene he adamantly intends to provide is precisely the scene that distorts the subject-matter. Unless it is possible for the scholar to insist that the film satisfy his own demands at all times, rather than those of the director, the film should not be made.

25. The immediate and unrelenting assumption of responsibility by the scholar and teacher must accompany the production of every item of material if that material is to be worth having in the classroom. It will be a matter of constant concern, and it will demand constant vigilance.

26. In the production of material, as in every other phase of the program, success and failure will only be established in the classroom. Materials must be tested in use, revised, tested once again, and continue in this fashion until there is good reason to believe that they are

achieving what they were designed to achieve. Every major curriculum revision has its chamber of horrors that houses the inspirations that failed when they were exposed to the student. On such occasions, there is nothing to do but try again.

The Preparation of Teachers

27. The student who is exposed to a new curriculum will have little trouble with it. If a course is presented to him as biology, he will accept it as representing biology as unquestioningly as he would have accepted the course it replaced.

28. His teacher is in a considerably different position. The teacher, if he has been any length of time in the school system, is already familiar with a biology course; he has taught it for years, he is familiar with it, and to him it is likely to represent biology. To be faced with a new course which may be entirely different in spirit and in content, and which nonetheless bears the same name and occupies the same position in the school, is somewhat disconcerting. It is also probable that the teacher will not understand it, and will not be able to teach it. Yet, as a practical matter, the new course must be taught initially and for many years by exactly such teachers.

29. Thus, the retraining of teachers becomes an inescapable part of the major curriculum revision. It must be built into the program from the very outset, and must be continued long after the major portion of the preparation of material is completed.

30. The first stage of this retraining is accomplished more or less automatically out of the necessity to associate practicing teachers with the program from the very outset. If the curriculum revision is to be realistic, it must have at all its stages the advice and guidance of teachers who are familiar with the exigencies of the classroom. Working upon the day-to-day affairs of the curriculum revision, and intimately familiar with the new materials as they develop, such teachers become retrained to a high degree of skill and comprehension.

31. Admittedly, their numbers are small—at best a small fraction of 1 percent of the teaching force which must ultimately be reached. Their value to the program, however, cannot be estimated by their numbers, for this small corps of highly trained, highly skilled teachers becomes the nucleus around which a major teacher-training program can be erected. In the United States, teacher training has customarily been carried on by the device of the 6- or 8-week summer institute, in which teachers are given an intensive course in the use of new materials and the rationale of the new course. The small cadre of trained teachers who emerge from the program itself are invaluable in helping direct the first of these summer institutes and beginning the process of rapid proliferation of trained teachers.

32. As part of the general teacher-retraining program, the curriculum revision should accompany all its material with a copious and encompassing teacher's guide. In the Physical Science Study Committee, this guide, detailed as it could be made, was treated from the outset as a major item, and handled as carefully as any other product. In size, the finished teachers' guide was far larger than the text. From it the teacher could extract all pertinent information concerning the learning material, from an account of the philosophy which animates

the course to the day-to-day detail of classroom procedures. It has become the teacher's *vade mecum*.

33. The problem of the initial training of teachers, in the United States at least, is a most difficult one. Institutions of higher education from which the great majority of teachers emerge, are for the most part, intensely conservative and have been resistant to curriculum change. As yet, no major program has been devised that would adopt the same approach toward curriculum in teacher-training institutions as the approach to the problem in the lower schools that is being described in this paper. In the absence of a direct attack upon this problem, however, much is likely to be achieved by the mere existence of new materials, which will ultimately force themselves upon the attention of the teacher-training institutions.

34. In the sections above, allusion has been made to the importance of the feedback process to the curriculum revision program. This process is an inescapable part of the development of suitable curriculum. Until materials have been tested in actual classroom conditions, and examined scrupulously in the light of those tests, there can be no assurance that the revision is achieving any one of its important goals. The entire program must be looked upon as an experiment, and until solutions to any given program have withstood the test of use, they must be looked upon as hypotheses. In the end, it will be students and teachers who must decide upon the soundness of those hypotheses.

35. The establishment of a feedback loop presupposes a certain flexibility on the part of the formal school system. Classrooms and teachers must be made available within the system. At times, the structure of an examination system must be loosened to assure that students who take part in the experiment will not be penalized in their academic progress. Since the introduction of a new course is a most arduous task for the teacher, the school system must cooperate by relieving the teacher of some proportion of his normal duties in order to provide extra time for this new one.

36. In this regard, the United States benefits from the benign anarchy of its educational system. With some 36,000 school districts, and an almost complete absence of any central direction, it becomes possible in the United States to carry on almost any kind of educational experiment—somewhere there is certain to be a school supervisor or principal who will undertake to assist. In countries with a more rigid educational structure, reform can be effectively blocked by refusal of conservative educational administrators to cooperate in the initial steps of curriclum revision.

37. We have dealt so far primarily with the mechanisms of curriculum revision. These mechanisms, like all mechanisms, are significant only in terms of the persons who are associated with them. The quality of a curriculum revision is a reflection of the quality of those who carry it out; the mechanisms in themselves produce nothing of value.

38. It must be recognized from the outset that the task of curriculum revision is one of the most difficult of all the tasks upon which the scholar or the research scientist can embark. Before he can hope to make a matter clear to the student, he must make it clear to himself, and where the subject-matter goes back to fundamentals, this can be enormously difficult. It is only when the scholar begins to prepare material for the

10- or 12-year-old that he begins to realize how much he is accustomed to take for granted within his own discipline, and how little of his basic material he has ever subjected to scholarly scrutiny.

39. Simply because it is difficult, it requires not only scholarship and skill, but the highest degree of scholarship and skill. Successful curriculum revisions have been those in which the most eminent men and women have been willing to suspend their own careers over a long period of time to apply themselves to problems of curriculum revision. Unsuccessful revisions have been those in which this association has been denied or has been limited.

40. The involvement of able men and women must be direct, and it must continue through the life of the program. Those qualifications which enable a scholar to make sound decisions on the selection of subject matter are exactly the qualifications required of the man who is to write the text, evaluate the feedback, make the necessary revisions, and, in general, see the program through to completion. If these obligations are to be delegated, they must be delegated to peers.

41. It must be apparent that curriculum revision is a time-consuming process. The history of the Physical Science Study Committee may be instructive in this regard.

42. The program began to take shape early in 1956, and by September of that year it had been established that there was a willingness among first-rate physicists to undertake the work that would be required. A formal organization began to take shape during the fall of 1956, and in December of that year 50 physicists and teachers, of national stature, gathered to lay the foundation of the revision. At that meeting, a tentative selection and ordering of materials was established.

43. Between December and June of the following year, drafts of textual materials were made by groups who had attended the initial meeting. In the summer of 1957, an 8-week workshop completed a draft of one-fourth of the text, began the preparation of the remainder, produced one experimental film and portions of another, designed laboratory experiments and the requisite equipment, began work on the teachers' guide and examinations, and engaged in activities looking forward to the creation of other materials.

44. In the fall of 1957, materials already produced went into eight secondary schools for classroom testing, and an organization was created within the Physical Science Study Committee to establish and run a feedback system. In the spring of 1958, a motion picture studio was put into operation. During the summer, another 8-week workshop was held. At the same time, five summer institutes trained some 300 teachers in the use of materials.

45. While production and revision continued, 250 schools experimented with the new materials in 1958–59. All classrooms, teachers, and students were carefully followed by the feedback process. The work of producing new materials and revising in accordance with feedback continued. Further, summer institutes were held during the summer of 1959, and during the academic years 1959–1960 the materials were used experimentally in 500 schools. Final editing took place during the summer of 1960, and in the fall of 1960 the course entered ordinary commercial channels.

46. At that time the course was by no means complete: many films remained to

be made and portions of the laboratory were still considered inadequate. However, the fall of 1960 can be established as the date at which the revision ceased to be experimental and became an established course. The period of preparation of materials and experimentation can thus be set at something over four years, during which some 800 schools and perhaps 1000 teachers were directly involved. It is worth remarking that the 1000 teachers constitute some 8 percent of the total pool of secondary school physics teachers in the United States.

47. It must not be concluded that the effort terminated in 1960. In addition to the materials which remained to be completed, the feedback process continued in operation, and is likely to continue into the foreseeable future. The date is already approaching when the text and associated materials should be revised, and for that purpose the feedback loop is essential. It is probable that any thorough-going revision of a portion of the course that may seem advisable will impose the necessity for renewed experimentation in the classrooms. In 1962–1963 operations directly connected with the use of the Physical Science Study Committee materials in secondary schools continue to run at approximately 20 percent of the peak that was reached in 1958–1959.

48. To some extent, this can be taken as a typical procedure for a major revision. To the degree that the Physical Science Study Committee was able to run at a full head of steam over its entire period of experimentation, the time-scale may have been shorter than that which will be experienced by other programs. In addition, it can safely be predicted that other disciplines, and particularly those within the social studies and the humanities, will prove far more difficult to handle and will require even more extensive experimentation than physics or the other natural sciences.

49. Finally, some remarks should be made about cost. The Physical Science Study Committee and most succeeding programs have adopted the principle that they must make serious demands upon the time of men and women whose time is extremely valuable both to themselves and to society, and that payment should be made for services rendered. Academic work is traditionally badly paid, and those who have engaged in curriculum revision are still badly paid in comparison to sums they might have earned in industry with a far smaller expenditure of effort. There has been, however, an attempt to elevate the rate of payment, and there has been a stubborn refusal to enlist assistance free or at bargain rates on the plea that it is "good for the country."

50. The cost of the revision during the period 1956–1961 was approximately $6 million, exclusive of teacher-retraining costs, which came approximately to an equal sum. Further experience with a wide range of curriculum programs will establish a sounder base upon which to make predictions, but it is certainly reasonable to expect that in the United States costs are likely to run in the neighborhood of $1 million per annum over a period of 5 years for any major program, and that a revision which relies heavily on the preparation of motion pictures will find it necessary to spend at least half as much again.

51. Continuing costs of the Physical Science Study Committee are now running at a level of $300,000 per annum, and are likely to continue at this level indefinitely if the course is to be maintained

at its present level of quality. Approximately one-third of this sum is devoted to activities which are intimately connected to the course but not central to it: preparation of special materials for advanced placement courses in physics, cooperative activities with foreign countries, and so forth. Here again, this may be taken, for the moment at least, to represent a fair approximation of what other revision programs may expect.

52. These costs should be measured against the total cost of the educational system, which in the United States runs at a level of $24 billion per annum. Total revision of the curriculum, on the Physical Science Study Committee scale, carried on over a period of years, could be carried at an annual cost of a small fraction of 1 percent of the educational budget.

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Specialized Training for the Improvement of Secondary School Teachers in Science and Mathematics*

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Introduction

1. Because of the rapid pace of development and expansion of scientific activity and technological procedures in all parts of the world, the roles of the teacher of science and the teacher of mathematics are becoming increasingly important. This paper is devoted and limited to a discussion of projects and procedures designed to contribute to an improvement in the effectiveness of secondary school teachers of science and mathematics.

2. To interpret this delimitation, it is desirable to describe some of the terms.

(a) A secondary school will be thought of as a school in which formal science instruction takes place for the first time in the education of its students, and in which considerable emphasis is placed on understanding rather than on rote memory and manipulation in mathematics. Such a school should usually furnish the final stages of preparation for entering the university or university college. Its students generally will have had between 6 and 8 (inclusive) years of successful primary school learning prior to admission, and they will generally be between 11 or 12 and 18 or 19 years of age.

(b) The effectiveness of a teacher relates to the rate of development of his students during their contact with him. An effective teacher must have an adequate mastery of the subject matter he teaches. He must also have a deep interest in his subject and be able to engender in his students, to the bounds of their individual capacities, an interest in and enjoyment of that subject.

(c) Improvement of secondary school teachers of science and mathematics means enhancement of their effectiveness. For purposes of interpretation of this paper, this should be taken to include at least the following:

(i) A more complete mastery of subject matter.

(ii) A keen sense of the roles of science and mathematics and of scientists and mathematicians in the development, maintenance, and operation of modern technological systems.

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*UN conference paper.

(iii) An adequate appreciation of the nature and importance of the development going on in or projected for the area in which his school is located. He should come and keep abreast of the knowledge assembled and disseminated relative to the human and natural resources in his area. Ideally, he should know, at any time, the extent to which these resources have already been developed, the rate at which such development is proceeding, and the specific locations at which significant development projects are planned or are under way.

(iv) An understanding of his role as a science or mathematics teacher in the development of his area.

A significant rate of progress toward a realization of at least these four items is indispensable. If any one of them is neglected, the rate of improvement must suffer. Furthermore, the advance toward the realization of these items must be begun without delay, and means must be continually and urgently sought to increase the rate of such advance.

3. It is germane to mention one topic without further reference. Some fruitful attention must be paid to financial remuneration and social status of teachers. Specifically, this means that these facets of the teachers' existence must be made both attractive and satisfying.

4. In the main body of this paper, outline descriptions of programs which might be expected to contribute to the improvement described in 2(c) are offered. Such programs will pertain to teachers-in-service and to teachers-in-training.

Principles of Design and Execution of Programs for Teachers-in-Service

5. The current condition of teachers-in-service relative to their effectiveness varies widely from area to area. For this reason it is necessary to design specialized training programs specifically for the teachers for whom they are intended. The following information is necessary.

(a) Details of the materials taught in science and mathematics in the secondary schools in the area. Some consideration should be given to necessary curriculum changes.

(b) Ability and readiness of teachers to present the material they are required to teach or may presently be required to teach. This information might be obtained through properly constructed survey tests. At least one organization is currently accumulating information relative to the solution of this type of testing problem (1). Care must be taken to develop a wholehearted support on the part of the teachers-in-service for this information-gathering and interpreting procedure. If inclusion of "modern" developments in subject matter is projected, the support of the teachers should be generated easily.

6. In less developed areas, the number of teachers-in-service is quite small, both absolutely and relative to the total population. The testing program suggested in 5(b) would, in general, involve small numbers of teachers. For example, in one less developed area of 80,000 square miles with a population of some 6,500,000, the total number of secondary school teachers of science or mathematics certainly does not exceed 150.

7. Immediately upon completion of the procedure suggested in 5, programs of instruction should be designed to meet

the indicated needs. Such programs in science would include much of the material of rudimentary physics, chemistry, and biology. A very heavy emphasis would have to be laid on improvization of laboratory apparatus, equipment, and supplies, using materials available in the local area (2). Each teacher himself would construct a minimum number of pieces of serviceable apparatus. This last requirement would be satisfied by all science teachers, even if they exhibited adequate mastery of subject matter. Programs in mathematics should include work with sets, sufficient to support a later study of the rational number system. Other elements in both programs would be selected by instructors as the program progressed. All lacunas in the individual teacher's mastery of the subject matter he is expected to teach must be filled. Additional more advanced work is desirable.

8. The problem of execution of such programs demands careful attention. All pertinent elements in the organization of the educational system involved must be considered. Detailed plans and procedures, feasible in specific situations, are required.

9. From the point of view solely of a very quick, very effective improvement program, it might be desirable completely to withdraw all obviously ineffective teachers of science and mathematics from their posts. At full pay plus expense allowances and credit for a year's experience toward salary increases, such teachers might be given, at a "central" location in the area, some 14 months of intensive appropriate academic work with pertinent practical overtones. In this way potentially remarkable change could be effected in science and mathematics teaching in a very short time.

10. The procedures presented in this paragraph were discussed with a number of persons engaged in teacher training in less developed areas. Each of them has pointed out obstacles, principally pertaining to public relations and rigid systems of examination and certification. However, they all thought the desirability of potential outcome of the proposed procedures make them well worth considering.

(a) Some details should be given.

(i) First, personnel units of teacher re-trainers should be recruited and organized. These should consist of two, three, or four persons each. The unit should consist of experienced teachers and teacher trainers, at least one of whom should be of local origin and experience. If foreign specialists are included, at least one of these should have successful experience in teacher re-training in his home country. The foreign specialist might be expected to do a large share of work in the early stages, but would later expand the work his unit would do and shift more of the responsibility to the hands of his associates.

(ii) Re-training units would be assembled as units, separately or severally, for orientation exercises. They would examine mathematics or science curricula of the area in which they would work, visit secondary schools in the area, and make contacts with the officials.

(iii) For each teaching personnel unit, appropriate if small libraries would be assembled, proper laboratory apparatus, supplies, and equipment would be accumulated.

(iv) It would be determined during this period whether a re-training center should be set up at some center having adequate space and facilities for the unit and its students. Alternatively, the unit could carry out its work by traveling, possibly in a properly equipped van, from one place to another to reach the teachers nearer their schools.

(v) The students would be organized into an appropriate number of groups, which would attend the re-training activity in rotation. The period of attendance would be at least 2 weeks. The work during this period would be intense. Before and after each period of attendance, reading and other work assignments would be made.

(vi) There would be two periods of attendance for each teacher during each school year. This would enable a teaching personnel unit to accommodate a maximum of seven groups of teachers. Under proper organization, this would mean that a teaching personnel unit could accommodate a maximum of approximately 140 teachers.

(vii) During the school vacation period the teaching personnel unit would conduct a 4- to 6-week session. During this session the work of the preceding year would be integrated, reviewed, evaluated, and extended, and preparations would be made for the following year's work.

(viii) The schedules of attendance and outside work during the second year would be essentially the same as those of the first year.

(ix) The second long school vacation would witness the completion of the retraining program for the units and for the teachers they had accommodated.

(b) It is obvious that the program proposed in 10(a), is strenuous, both for teachers-in-service and for teaching personnel units. However, a less strenuous program cannot hope to meet the current and prospective need.

(c) In at least some less developed areas, the type of re-training procedure suggested in 10(a) would be feasible. The procedures and time schedules described therein could be modified to meet the needs of specific area conditions. Furthermore, it might be possible to adjust the intensity and the elapsed time involved. A continuing review and evaluation procedure would have to be carried out.

(d) The secondary school teachers of science and mathematics now in service in less developed areas form a very small part of the corps of such teachers who must very soon be in service. For this reason the re-training program of 10(a) represents only a small portion of the total job to be done. At least one, and perhaps several, subsequent emergency re-training programs will have to be carried out to take care of teachers now being trained. In the meantime there must be emergency re-training programs for teacher-training personnel.

Programs for Teacher Training Personnel

11. In order to insure the adequate preparation of teachers of science and mathematics for the future, it is essential to give careful attention to teacher preparation procedures and to the personnel now doing this work. We here introduce the term *instructor* to indicate a *teacher* (not a student) in a *teacher training institution.* Many instructors have had at least a part of their own training outside

their own countries. This practice should be continued and expanded. The offering of a substantial period of study abroad for outstanding students who engage to return home as instructors will certainly constitute a powerful incentive.

12. The following emergency re-training program for instructors (see paragraph 11) is presented as one which could yield results in a short time. While this program is not presented as the unique optimum program, it must be emphasized that a lesser program would be self-defeating and futile. Hence this program is an absolute minimum.

(a) The numbers of instructors are rather small. The program here outlined would involve a small operation.

(b) The program could be started almost at once, provided personnel could be recruited and active cooperation of locally responsible officials could be enlisted.

(c) Teaching personnel units of two to four persons each should be recruited, each containing at least one experienced teacher training expert and at least one person engaged in some teacher training activity in the area in which the unit would work. It is desirable to have in the unit some teacher-trainer from outside the area.

(d) Each unit should have a center of operations. These centers should be equipped with library facilities, laboratory space and equipment, and class rooms.

(e) All instructors within the area serviced by the unit should be effectively invited to spend all the periods of vacation from school, except possibly a few days holiday, working at the center.

(f) The unit and the instructors (see paragraph 11) should spend at least half their time in enhancing the subject matter competence of the instructors. Some of the instructors could act as leaders in this procedure, but the unit's personnel should be prepared to carry whatever load might be required of them. The classroom presentations should be models of good pedagogical practice.

(g) The remainder of the time should be used for curriculum studies. Considerable attention should be given to an examination of the area's stage of development and the roles of science and mathematics and of science and mathematics teachers in its continuing development. In some schools mathematics and science are taught with aims rigidly fixed on certain crucial examinations, many of which do not adequately stimulate interest either in the subject matter itself or in its relation to the problems of the societies in which they are set. The instructors must accept the responsibility for supplying these needed stimuli, hence they must be prepared for this function.

(h) Attention should be given to the problem of improvising laboratory equipment by using indigenous materials. While teacher training institutions should have reasonably equipped and usable laboratories, their graduates will, for some time to come, have to make do largely with improvised apparatus. Fortunately, some work has been done on this important problem (2). Some schools have no laboratories of any kind. A working laboratory should be in the re-training process in all cases.

(i) Modern computing methods should be discussed.

(j) Attention should be given to the art of constructing (setting) and interpreting examinations. Instructors should be made aware that there are workable alternatives to rigid crucial examination schedules.

(k) During the school term, the unit, either as a unit or in personnel pairs, should tour the teacher training institutions of its area. If proper rapport is established during periods of attendance at the center, then very useful cooperative procedures can be established at the several teacher training institutions. Such procedures would involve reciprocal observation and evaluation of the unit's teaching procedures by the instructor, and vice versa.

(l) This alternation between work at the unit center and cooperation and individual work during school time should continue over a period of about 2 years. A tremendous incentive for energetic and purposeful work would be prizes consisting of substantial periods of study abroad.

(m) Although the period envisaged in 12(1) is 2 years, it should be the responsibility of the unit to recommend revision of this period at any time during the planning and operation of the program.

Currently Effective Approaches to the Problems of Designing Specific Re-training Programs

13. Individual programs must be designed specifically for each area involved. Such programs must take into account all pertinent aspects of the local situation. Every ethical effort should be put forth to gain the support of affected persons, organizations, and officials. Descriptions of programs must be made available and their purposes and intents carefully explained.

14. Some areas have already faced the problems of improving their teachers of science and mathematics. Descriptions of their programs appear for example in the monograph: *Programs for the Improvement of Secondary School Education in Science and Mathematics* by Bowen C. Dees, Assistant Director for Scientific Personnel and Education, National Science Foundation, Washington 25, D.C. Additional information will certainly be available from the UNESCO Publications Center in New York.

Programs for Well-Trained Teachers

15. In almost every area there are well-trained science and mathematics teachers. They must not be neglected. One strong incentive for excellent work is the prospect of a substantial period of study, observation, and travel abroad. A competition might be organized, on a temporary or continuing basis, in which the awards were fully financed for periods of from 3 to perhaps 15 months. An essay on the reason for the teacher's (or instructor's) desire for such travel and study and on the relation of his work to the continuing development of his area should be required in such a competition.

Continuing Programs

16. Concurrently with efforts to re-train teachers now in service, there must be programs for the improvement and expansion of regular teacher training programs. One of the most urgently needed early accomplishments is the elimination of waste wherever it occurs. In this connection, it will be hard to justify the continuation of teacher training institutions with small numbers of students. The problems of effective organization and efficient operation are two which must be attacked with determination and vigor.

17. At the same time that the ideas in 16 are pursued and expanded, a review of

teacher training curricula should be begun. Revisions and corrections should be made where indicated. Some experience in this procedure has been accumulated in some developed countries. Descriptions of some such specific programs, appear in John A. Brown et al., *Promising Practices in Mathematics Teacher Education,* School Science and Mathematics, *58,* 25–40 and 435–444 (1958) and in George A. Mallinson et al., *Promising Practices in Science Teacher Education,* School Science and Mathematics, *58,* 13–25 (1958). A description of a currently conceived long-range goal appears in *Recommendations of the Mathematical Association of America for the Training of Teachers of Mathematics,* the Mathematics Teacher, *53,* 632–8 and 643 (1960).

18. The techniques of teacher education are in a dynamic state. Teachers in teacher training institutions should be alert to the situations relative to such techniques and should adapt appropriate elements and devices to suit their purposes.

Organizations of Teachers of Science and Mathematics

19. During the emergency re-training procedures described in 10(a) and 12, area-wide organizations of teachers of science and mathematics should be initiated. These organizations should recruit members from all segments from the universities to the primary schools. They should limit their efforts to the improvement of science and mathematics instruction in schools. This would include energetic development and dissemination of ideas on the subjects of interest. It would include the publication of some periodical, devoted primarily to the instruction in science and mathematics. The organization should establish and maintain working relations with similar organizations in other areas. Regular exchanges of publications, ideas, and perhaps personnel should be arranged. Appropriate lecture series should be organized. Public relations activities, including cooperating with available mass media of communication, should be entered into.

Further Considerations

20. In all specialized training programs for the improvement of secondary school teachers of science and mathematics, energetic and continuing effort should be put forth to encourage the extensive participation of local personnel. Talent searches should be conducted. Talented persons found in such searches should be educated thoroughly in preparation for their early assumption of responsibility for the on-going training program. An integral and essential part of training programs should be the emergence of an adequate cadre of indigenous personnel to staff the continuing program and later to assist in the design and execution of similar programs for other areas.

21. Experience in the use of television, motion pictures, and so-called "programmed teaching" and "programmed learning" procedures and other devices and procedures is being accumulated. Advantage should be taken of this experience as it becomes available. In the United States, organizations active in these respects include the School Mathematics Study Group at Stanford University, Educational Services Incorporated in Watertown, Massachusetts, and Lab-

oratory for Educational Materials, New York City.

Conclusion

22. A comprehensive program of specialized training for the improvement of secondary school teachers in science and mathematics cannot exist in isolation. Such a program impinges on many allied and associated activities. The elements described in this paper should be considered only as general suggestions to be taken into account in any specific planning procedure. Plans for any area should be made specifically for that area, taking into account its peculiar opportunities and problems.

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Specialized Training for Developing Basic Scientific and Technological Cadres in Developing Countries of Africa*

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Support of Specialized Training by General Education

1. Trained manpower is customarily classified into three levels:

Vocational—semiskilled and skilled[1] workers
Intermediate—factory and laboratory technicians, non-graduate technical instructors
Senior—graduate scientists and engineers, managerial personnel

2. *The Vocational Level.* Industrialists and educators in most countries consider 2 to 3 years of post-primary education as the minimum necessary for efficient specialized training at this level. In French speaking African countries, the 2 years of post-primary education previous to craftsmen training are automatically included as "le tronc commun" which consists of "la 6^{e}" and "la 5^{e}" and leads to further studies for the Certificat d'Aptitude Professionelle (CAP). In English-speaking African countries, this approach is now gaining strength (1). Thus, on the recommendation of this author (2), the Western Nigeria Ministry of Education is presently reforming the so-called Secondary Modern School (a 3-year course following the 6 years of primary school) by introducing general science and workshops (metal and wood) as obligatory for all students in the first 2 years of this school, and has requested support for this purpose from the U.S. Agency for International Development. Observation and testing of students during these 2 years—which thus correspond to *le tronc commun*—will be used to channel them in the third year into different groups according to their abilities and aptitudes. One of these groups will be "pre-vocational", and will get one more (terminal) year of general education with a strong practical bias consisting of applied science (elementary technology), technical drawing and workshops. Those who leave the terminal class will either enter vocational schools (Trade Training Centers) or take up employment with industry; in the latter case they can be, thanks to their pre-vocational background, easily trained "on the job" as semi-skilled workers (factory operatives, artisans). Pre-vocational bias will

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*UN conference paper.

also permit reduction of the length of craftsmen training.

3. *The Intermediate Level.* In English-speaking Africa, the W.A. School Certificate, (normally taken after 5 years of secondary school and equivalent to the Ordinary Level of the British General Certificate of Education) with passes in English, mathematics, and appropriate sciences, is considered necessary as a prerequisite for normal entry to a technical college for training technicians. The Western Nigeria Ministry of Education is now introducing in the grammar school (3) pre-technical streams in which advanced workshops, technical design and engineering science will be taught besides normal general education subjects. This again will facilitate the training of technicians and leave room for enriching the curriculum of the technical college. In French speaking Africa, specialized training of technicians takes place in lycees techniques and colleges techniques and is thus automatically based on general education included in their programs.

4. *The Senior Level.* In French-speaking territories the Baccalaureat, which is the prerequisite for training scientists and graduate engineers in universities, provides a broad enough base of liberal arts (including philosophy) for advanced specialized training. In English speaking territories the Sixth Forms emphasize specialization too much. At least in Western Nigeria, it is felt that the specialization beginning in the Sixth Forms would be more effective if it were accompanied by considerable broadening of general education. The Western Nigeria Ministry of Education, with the support of the Agency for International Development, is expanding the program of the Sixth Forms in its Ayetoro School (see below) by adding 14 periods a week of obligatory general subjects to the 21 periods a week devoted to specialization. These general subjects are: History of Philosophy and Science, History of Art, Introduction to Logic and Psychology, Political Science, and African Problems (sociological, economic etc.). After the Sixth Forms the students may enter the first year of a British-type university; or they will have grounds for requesting "advanced placement" in an American-type university, since several subjects they have taken would have been at the same instructional level as that prevailing in the first two years of an American university.

5. *The Comprehensive School and Technical Training.* The Comprehensive School, with its combination of general education and elective biases is the best preparation for specialized training at any level. The Western Nigeria Government, with support of the Agency for International Development, has established a Demonstration Comprehensive Secondary School at Ayetoro, and the Graduate School of Education, Harvard University, is operating it under an AID contract. The Ayetoro Demonstration School, planned by Chief Inspector of Education Mr. Somade and this author (4) is meant to serve as an experimental "laboratory" for the educational reforms in Western Nigeria. Its main characteristics are: (a) a three step structure, each of the steps providing general education with elective biases for specialized training at each of the manpower levels quoted in paragraph 1; (b) introduction of new course content, particularly in mathematics and the sciences, based on the materials prepared in the United States under the auspices of the National Science Foundation but revised and adapted by special writing groups composed of Ni-

gerians and Americans; (c) inclusion of vocational education in the program of the school to foster the status of the craftsman in the society. Yearly conferences on the progress of the school will be held with specialists invited from abroad (United States, United Kingdom, Sweden, etc.) to profit from their constructive criticism.

Planning for Training Schools

6. When "big" industry starts or expands a plant in a developing country, the first operational stage is directed and supervised by the company's own experienced graduate engineers and technicians. Only when plant operations are well under control, does the company seek to replace its own staff by local engineers and technicians. Semi-skilled and skilled local workers, are, however, needed at once. The former (operatives, artisans) can be trained in the factory "on the job" (see above). But training of fully competent craftsmen requires a minimum of two years and special facilities, which industry may be unable or unwilling to provide; the Government must thus plan for Technical (Craftsmen) Training Centers well ahead. Surveys of anticipated manpower needs should be therefore held as frequently as possible and their results (numbers, fields) communicated to the Ministry of Education. In the absence of such survey data, the number of training places needed can be roughly estimated from the capital investment planned for industrial development. For instance, investment of about £3,000 in "big" (highly mechanized) industry usually opens one job at the vocational level, while in the case of small private industrial or servicing enterprises such a job may require only about £200 capital investment. In this employment aspect lies the value of small private enterprises for developing countries.

7. From the numbers of trainees at the vocational level one can roughly estimate the needed number of technicians (one for every ten vocational trainees) and of graduate engineers (one for every five technicians). The above ratios are only a rough approximation and they do not apply to the sector of small private enterprises, since technicians are not needed to supervise small independent entrepreneurs. Also in the important construction industry, because of the way it is operated in Africa, far fewer technicans and craftsmen are needed than indicated by the above ratio. Using the above ratio indiscriminately for estimates of numbers of the needed technicians and vocational personnel from an estimated output of graduate engineers must therefore lead to unrealistically high figures (5).

8. In Craftsmen Training Schools, one instructor per maximum of 20 trainees and, in Technician Training Schools, one instructor per 10 trainees should be anticipated in planning. Under these circumstances the yearly current expenditure per one craftsman-trainee amounts, in English speaking territories to about £200, and that per one technician-trainee to about £500. Capital investment depends on fields of training and on presence or absence of boarding facilities, the order of magnitude being that of £1,000 per craftsman-trainee.

Content (Syllabi) of Specialized Training

9. *The Present Situation.* Most semi-skilled workers are trained "on the job" either in factories or with private "masters" and acquire only manual skills

without much understanding of the underlying technology. Short upgrading courses are occasionally arranged for them by the Government agencies and industries, but this is far from being widely spread or systematic.

10. The training of craftsmen takes place in Government Technical Schools (Centres d'Apprentissage or Trade Training Centers, respectively) in Government agencies (public works, railways, etc.) and in organized training schemes operated by some big industrial firms. Most craftsmen aim at Certificat d'Aptitude Professionaelle (CAP) or at the CGLI (intermediate) Craftsman Certificate, respectively, as their formal qualifications. Apprenticeship schemes are patterned on those of the respective ex-colonial countries and are, in general, of 5 years duration. The formal training syllabi, particularly in English speaking countries are often unrealistic. For example, a painter-decorator in Nigeria must acquire skill in wallpaper hanging, although wallpaper is not used in Nigeria: it mildews; a bricklayer in Nigeria must learn to lay complex variants of brick bonding and build several kinds of fireplaces, although none of these skills is in demand on Nigeria's labor market.

11. The training at the intermediate level is geared either to the Brevet d'Enseignement Industriel or to the CGLI Ordinary (seldom Higher) National Certificate and takes place in the Lycees (Colleges) Techniques or in Technical Institutes (Colleges), respectively. The need for trainees at this level is particularly acute in all African countries.

12. At the senior level there are, at present, only about 13,000 African graduates in the 27 countries south of the Sahara which obtained their independence (or are in the process of obtaining it) since 1954 and which represent a joint population of over 140 million. The distribution of these graduates is very uneven, about 9,500 of them being concentrated in Ghana and Nigeria. African universities—hardly over a dozen of them in the territories referred to above, and most of them in an early stage of their development—follow in the content of their studies and in the structure of their degrees the pattern of their respective ex-colonial countries, with the exception of the University of Nigeria, at Nsukka, which attempts to set up a new pattern based rather on the American than on the British approach. In recent planning, special attention is given to training of scientists and engineers, but the facilities are still very scarce. The majority of the senior staff is composed of expatriates.

13. *Suggested Measures.* The training of semi-skilled workers depends largely on the type of skills required in the industries which are to employ them, and it is therefore difficult to organize it effectively in government-operated technical schools. The opinion is markedly growing that training at this level should be organized by the industries themselves, mainly on the "in plant" training principle, with the Governments giving whatever help they can particularly by introducing pre-vocational subjects (workshops, technical design, science) in general education which precedes specialized training (6). This new approach, besides being practically sound, relieves the Governments of considerable financial burden (the semiskilled workers forming the most numerous layer of trained manpower) of providing student places in technical schools and should be generally accepted. More detailed recommendations appear below.

14. The training of craftsmen should be the responsibility of the Governments, but the latter should make all efforts to encourage the big industries not only to continue their existing craftsmen training schemes but to expand them and set up new ones. This encouragement should take the form of financial incentives (by allowing industries to write off as current expenses the cost of equipment, of buildings and of instructors used for this purpose) and even by direct subsidies per industrial trainee. Even a subsidy of £150 a year per industrial craftsman trainee would, in effect, save the Governments the respective capital investment and a part of the current expenditures (7).

(a) All training syllabi at the sub-professional level should be revised and adapted to the actual labor market needs. New trades (skills) required by local conditions (agricultural products processing, rubber processing etc.) should be given a formal status and their programs of training should be designed by local professionals, technicians and craftsmen. While some changes of syllabi are possible even under the present dependence from Overseas Institutions (such as CGLI) and while the respective proposals should be formulated as soon as possible by committees composed of the respective technical instructors who have had experience in Africa and should be forwarded to the overseas institutions for their approval—the only permanent solution is the creation of Regional African Technical Examination Boards (Councils). Because of the lack of senior technical African personnel, these Boards would have to, for some time to come, rely to a great extent on the help of the existing Overseas Examination Boards and should discontinue this dependence only gradually, as their own personnel strength and experience increase. The West African Examination Council, with headquarters in Accra, is a good example of such a development in general education and should be imitated in specialized training at all sub-professional levels.

(b) All sub-professional syllabi should include the teaching of management, particularly that of small industrial and servicing enterprises.

15. Senior level training and research could get additional support by the creation of:

(a) *Institutes of Applied Science and Technology,* organized on a geographical basis (arid zone, tropical zone, coastal zone), should explore new fields of development in the fields of agricultural products (and their local processing), of sea and coastal resources, of industrial products particularly suited for Africa, of hydrological and geophysical research, etc. In cooperation with African universities and big industries, they should help train specialized senior research cadres. In the first stage of their activities, these institutes would have to be heavily supported by foreign financial assistance and draw upon the specialist resources of consortia of foreign universities, learned bodies (Academies of Science) and research institutions.

(b) *Educational Research Institutes (Councils),* preferably organized on a politically regional basis, should study the process of teaching and learning of African children, work out more suitable selection and testing procedures (in the latter field they should join the CCTA programs) and explore the best ways and means of fostering Anglo-French bilingualism, particularly among the school children. In Nigeria, such a Council is presently being organized at the federal level with the participation of all Regional Nigerian Ministries of Education and all Nigerian universities.

16. Both above named institutions should maintain close liaison and cooperation with the African Technical Examination Boards (Councils) so that the latter might profit from the new findings in designing special training syllabi that would be sound and realistic in their content as well as in their pedagogical approach.

Government-Supported On-the-Job Training

17. As indicated previously, the training of semi-skilled workers is, at present, only too often restricted to learning manual skills without any understanding of underlying technological principles. This is true particularly in the case of apprentices employed by private "masters" and by smaller industrial plants.

18. For these apprentices, the Government Technical Schools (Centres d'Apprentissage, Trade Training Centers) should operate special courses aiming at: (a) complementing manual skills by theoretical background (principles of the related technology, related technical drawing, related mathematics), (b) improving the apprentices' mastery of the official language of their country, particularly within the requirements of their trade, but also for the sake of encouraging general reading, (c) demonstrating the use of modern machinery which the apprentices might not have encountered in their own practice, and (d) teaching them elements of management of small private business enterprises.

19. Although for some time to come these courses will have to be operated in the evening, the African Governments, as soon as their Technical Training Schools have been sufficiently expanded, should press for the passing of legislation that would compel employers to release their apprentices during their legal working hours and on their usual pay, so that they might attend the "improvement courses" to the extent of 150 hours a year during at least 3 years.

20. For workers in small industries which are grouped far from the established technical schools, special demonstration mobile workshop vans, manned by competent instructors, should be used for conducting such courses by travelling from place to place. The vans and their instructors would be normally based in the nearest technical school; but special industrial development centers could be established for this purpose. Such Centers are now being built in Nigeria by the Agency for International Development under an agreement with the Government and will serve, at the same time, to improve techniques (and management methods) of existing small indigenous enterprises.

21. For craftsmen already well established in their trades and for the intermediate personnel, refresher courses, upgrading courses, and courses in new techniques should be operated in the government technical colleges in the evening.

22. For the Senior Staff, the Institutes of Applied Science and Technology should arrange special refresher and new techniques courses; also, from time to time, a symposium, arranged on a re-

gional basis, should acquaint the senior scientific and technical staff of the Nigerian universities, the industrial firms and government corporations and agencies with the progress made in selected fields of the Institute's activities.

Training of Technical Instructors

23. It has been indicated several times previously, that an adequate pre-vocational and pre-technical preparation of the secondary school students plays an important role in increasing the efficiency and reducing the cost (time) of their further specialized training. This preparation includes teaching workshops (wood and metal), elements of technology (particularly that of metals) and technical design. To provide teachers of the above subjects, it is proposed to establish special Workshop Instructors' Training Centers. These would take entrants holding the GCE (Ord.), or the Brevet d'Enseignement du Premier Cycle who have had passes in sciences (physics and chemistry) and give them a 2-year (after GCE) or a 3-year (after B.E.P.C.) course in woodwork, metalwork, technical design and principles of technology, plus another year in pedagogics and methodology of technical instruction. These instructors should be treated as Grade 1 teachers, as far as their salaries are concerned. Nigeria has recently applied to the Scandinavian countries for support of such a teachers training center.

24. African technical instructors for trade training centers (Centres d'Apprentissage) are now being predominantly trained abroad. For the sound development of African technical education it is necessary that higher levels of craftsmen training (e.g. those corresponding to the CGLI Final and Full Certificate) be operated locally. It is this level that is required as qualification for technical instructors in craftsmen training schools. Extensive industrial practice should also be required of future technical instructors. The course for training of technical instructors in their trade should be of two years duration followed by an additional year of pedagogical training. Pedagogical training of all technical instructors should be mandatory. The instructors who have not yet acquired such training should take it in a technical teachers training college, of which one should be sufficient for each African country. If such a college is not available (or the country is too small to afford one) technical instructors should take a year's pedagogical course in an ordinary teacher training college or in a university-operated scheme for pedagogical training of technical instructors (University of Nigeria, at Nsukka, plans to operate such a scheme).

25. Lecturers in technical college (forming technicians) should also possess additional pedagogical training. Since such lecturers must be university graduates or otherwise have "professional standing" in the English speaking countries by being active members of respective professional institutions, their pedagogical training should be arranged in the universities as a 1-year course. The latter could be divided into a series of vacation courses with a cumulative effect leading to a diploma in Education.

26. The sound progress of both general and technical education in Africa seems hardly possible without introducing substantial changes in the content of the present syllabi (8). While the African Examination Councils (both general and technical) will have to decide, eventually, as to the acceptability of the new syllabi,

the work on the improvement of the syllabi should be initiated as soon as possible, and should become a "grass roots" movement. To achieve this, African teachers should become acquainted with new developments abroad in course content. With such aim in mind the Government of Nigeria has organized, with the financial help of the Agency for International Development, vacation seminars (of 6 weeks duration), in which American lecturers, selected by the National Science Foundation in Washington, presented the content of new American-developed courses for secondary schools in physics, chemistry and mathematics to qualified Nigerian secondary school teachers, and received their suggestions as to the necessary amendments that would make these courses applicable for Africa.

27. Such courses should be held annually in all African countries, both French and English speaking. Out of them writing groups should emerge, composed of the Africans and expatriates, who would outline new text books and teachers' manuals for use in schools on an experimental basis. After sufficient experience has been gained, the Examination Councils should be approached for recognizing the new course content and allowing the schools to set up the corresponding examinations.

28. The National Science Foundation and Educational Services Incorporated have considerable experience in the domain of creating new course content, and should put their resources at the disposal of African countries. The courses, mostly to be operated during vacation, might be supported by the Agency for International Development, or the American foundations.

FOOTNOTE

[1] Craftsmen (skilled workers) are, by definition adopted by the Nigerian Employers Consultative Association, capable of performing their work without direct supervision; artisans (semi-skilled workers) require direct supervision by a craftsman.

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Books and Economic Development*

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1. Education is the basic capital investment for economic development. Nearly every sophisticated observer will acknowledge that truism nowadays, but it is important to emphasize that education intended to lay the foundation for economic development must include more than conventional classroom work. The requirement is not only for public school systems as normally conceived but also for manual and other vocational training, business and public administration (in-service programs as well as others), and provision of the means for self-education.

2. Reading is the basis of education. In the very act of undertaking education—of equipping students with the mechanics of reading—a country comes face to face with the problem of providing reading material.

3. Books have long demonstrated their effectiveness as the basic tools of reading, and hence of education. Books are most effective only if their use is coordinated with all other media of communication, including particularly radio, television, films, and other audio-visual techniques and devices. In this day none of these methods can be considered in isolation from the others. But without books and other printed materials to intensify and support the educational function of the other media the effect will be transitory and superficial.

4. An indigenous book industry is the only means of producing books fully responsive to local needs and interests. It is therefore an essential element of economic development in any country. It cannot be prefabricated and "laid on" from abroad. It must grow in local soil and in closest articulation with local education. Useful as foreign books may be for some purposes, and especially during an interim period, they cannot serve the continuing need. A local book industry is required for these reasons:

(a) To enhance self-reliance and self-respect, thereby increasing the acceptability and hence the usefulness of the books to be published.

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*UN conference paper.

(b) To permit books to be suited to local conditions and especially to the educational plans of the country concerned. This is obviously essential for most books for in-school use, but it is necessary in other areas also, for instance "how-to" books (because of geographical variation in tools, materials, agricultural and trade practices, etc.) and even books for self-improvement through recreational reading.

(c) To narrow the gap between thinkers and doers in a society, serving not only to "put knowledge to work" but also to close the spiritual breach between intellectual leaders and active participants in day-to-day work or in the direction of affairs. In very few developing countries do teachers and other workers with words know even the vocabulary, let alone the ways of thought, of people following a trade; the would-be writer of a book on masonry may not even know the common word for a trowel. A local book industry can bring about useful teamwork of thinkers, teachers, and doers.

(d) To permit speed and flexibility in supplying the market, which cannot be properly served from a foreign country.

(e) To build the mechanism for continuing to make books available in the future instead of merely supplying particular books needed at the moment.

(f) To permit efficient publication of books in mother tongues which, in most developing countries and at most levels of readership, at least at the outset, are needed instead of books in foreign languages.

5. Creation of a book industry is not very difficult. If, as in most countries, some rudiments of such an industry exist already, it is quite easy to stimulate and aid expansion of some of its parts, without even waiting for the integrated overall development that an ideal national plan should prescribe. Although a book industry's influence and usefulness extend into every nook and cranny of the national economy, its own requirements in capital and in technical training are relatively modest. The basic needs for a book industry are:

(a) Support from the intellectual and civic leadership of the country, and especially from the directors of education and the economic planners.

(b) Personnel-training for the staff of publishing and printing establishments is a basic need. Of the chief elements in the total publishing operation, only the manufacturing phase (printing) involves mechanical techniques difficult to learn. Eventually every country should have schools of printing for meeting that training need; but on-the-job training, under foreign technicians where necessary at the beginning, is extremely useful, and selected managerial personnel can be given training abroad as a supplement to that. For publishing and distribution, in which areas the personnel shortages are gravest in most developing countries, experience shows that, for the right people, relatively brief periods of observing methods in developed countries, supplemented by some consulting advice, can be adequate, without need for elaborate training programs. The mental level and the imaginative power of editorial personnel must be high, and those who take part in distribution should have outstanding business competence. But the techniques themselves are not complicated and can be mastered in a very short period of time.

(c) Printing-plant capacity for supplying today's needs is inadequate in nearly all developing countries, and nowhere is there enough capacity to meet the requirements that will develop in the next three years, let alone the more distant future after educational systems are under full headway and the number of potential book readers has multiplied several fold. On the other hand, there are some plants (and an initial cadre of workers with some training) in virtually every country; and printing is a happy example of an industry capable of development in either large units or small units. In particular circumstances a country may either expand or supplement existing elements or undertake clean-sweep construction of entirely new large plants. Although, for certain kinds of printing, the large plant has clear economic advantages, there are other kinds of printing handled at least as well by small units. In other words, printing development does not have to be of an "all or nothing" sort. A country can start with what it has or with nothing at all, work toward any desired objective with development units of any size, and in either the public or the private sector or in a mixture of the two.

(d) Materials for the printing and publishing industry are required in large volume in the case of only one commodity—paper. A paper industry is "heavier" than printing, and in general does not prove economically feasible in small units. The economic questions involved in deciding whether to undertake local manufacture of paper are therefore more momentous than those relating to printing itself. It is a fact, however, that raw products usable in some kind of paper manufacture (rice-straw, bagasse, bamboo, jute, as well as conventional timber) are abundantly available and frequently going to waste in many developing countries. A local or a regional paper industry is therefore a fit candidate to consider for inclusion in a country's general plan for economic development. Besides paper, other materials required in continuing supply for a book industry, though in monetary outlay far below paper, are ink, adhesives, offset film, type metal, binding thread and cloth, stitching wire, metal or plastic materials for platemaking, varnish and plastic coating, inked or metallic binding foil, and of course spare parts for machinery. Some of these may eventually be manufactured locally, but if not it is essential that the national plan arrange for suitable conditions of import so the development of this small but critical industry will not be choked off at the customs house.

(e) Minor service industries supplying goods or services to groups of plants might include type-founding or the making of "sorts" by typecasting machines, the recasting of printing rollers, and platemaking, as well as manufacture of some of the materials listed in (d) above, such as ink, adhesives, thread, etc. Local industries of this sort are not absolutely essential; the needs can be met from abroad, or major plants may wish to perform some of the operations themselves. These small industries are attractive in economic-planning terms, however, as representing very small units with generally modest requirements for capital and number of trained personnel.

(f) Working capital is not required in any enormous amount, but it must be available to a sufficient extent, and on a reasonable enough basis, to permit the publisher the economy of large editions even though the sale of those editions will stretch out over a period of time.

The concept of small business loans at non-extortionate interest is needed in many sectors of a developing economy, but in few cases as clearly as in the case of printing and publishing. In theory the printer's working-capital investments do not take long to come back to him, because his customer (the publisher) is supposed to pay for each job as soon as it is finished. But if the publisher has insufficient cash leeway while waiting for the return on his editions the printer will suffer in turn. The need is to find how to finance printing-publishing as a whole according to some means that will permit editions of efficient size, yet allowing enough time to sell such editions without starving out the industry in the interval.

6. Regional development of printing and publishing is a logical possibility in purely economic terms. It makes eminently good sense if one can forget about politics and psychology. But because of the sensitivity of book-publishing in terms of ideology and national pride, it is difficult to start on a regional basis. Much more promising is an initial decentralized approach, with a pragmatic regional development coming later, perhaps at first in connection with purely ad hoc projects rather than with a grandiose regional plan likely, in the abstract, to arouse both commercial jealousy and nationalistic passions. Among the elements lending themselves to regional treatment are some of the minor service industries referred to above; training programs for personnel; joint runs of presswork for color illustrations; and joint runs of presswork for the common factor in books designed to have some locally-modified sections to suit each country but with the bulk of the book being uniform for all. As an example of the last: a world geography for use in the French-speaking portion of West Africa might have identical maps and text for the sections of the book dealing with the world and with Africa in general, and the pages for those sections might be centrally printed; but a locally written section, varying from country to country, could be added for detailed treatment of Guinea, Senegal, Ivory Coast, etc. for the copies of the book to be used in the respective countries.

7. International cooperation is needed if the developed countries hope to assist developing countries in attaining the desired ends. Assistance through international organizations such as UNESCO and OECD is one of the methods. But in training programs, in provision of capital and equipment, in readiness to aid regional development, in provision of help for translation and reprint programs where those are locally desired—in all of these phases—there is wide scope for multi-national as well as formally international cooperation. The special competence of the Scandinavians and Japanese in paper-manufacture, of the Germans in the field of pressroom and simple binding equipment, of the British and Americans in type-casting machinery, suggest the benefits that will result from the participation of more than one country in development plans relating to publishing and printing.

8. Developing countries have useful information and experience to exchange among themselves. A book industry which has arisen significantly in a recent period—the Iranian book industry, for example—is in many ways a more valuable training ground for people from other developing countries than the European and American industries that seem to the beginner to be light-years

away and in any event have achieved their present status over centuries of time.

9. Books from foreign countries, whether in their original editions, in inexpensive reprintings in the original language, or in translation with or without adaptation, have an important role to play; but the nature of that role will change as time goes on. Even for school textbooks it is possible that suitably adapted reprints or translations of books from abroad can sometimes meet a desperate interim need (especially in the "skill" subjects of reading, writing, language, etc.) while the local country is learning how to produce its own. This sort of need will disappear as the local industry acquires competence in creating and producing books, but the need for some kinds of books from abroad will never end. Indeed, as in the United States and in Europe, the need for many kinds of foreign books in both the original language and translation will grow in proportion to the development of the local country's own industry and the broadening of its education.

(a) Especially in the case of countries with a mixed linguistic pattern of mother tongues but using a European language for instruction at all higher levels of education (e.g., India, Pakistan, and many African countries), the market for general-reading books and many kinds of university textbooks in original or reprint editions in the appropriate world language will continue to grow. In some other countries with mixed mother tongues but an effective national language (e.g., Indonesia) such books in translation into the national language will always be needed. Even in the most locally-oriented of all book fields—recreational-reading for children—translated books serve an indispensable purpose in broadening horizons, injecting new ideas, and developing a concept of world unity.

(b) Bookmen from developed countries who wish to aid the developing countries have a high responsibility to distinguish between the interim and the continuing function of foreign books; and in either event to purge their own souls of linguistic or cultural or economic chauvinism. They will serve their own countries and their own cultures best if they keep in mind, as the primary criterion in everything they do, the educational welfare of the country they are trying to assist.

10. Support for a local book industry must come basically from the country itself. Foreigners can help with ideas and capital and personnel-training and by suitable arrangements for translation and reprint programs where desired, but unless the local country itself is determined to make a book industry a part of its national development, not much progress can be made. The need for local support is not limited to the questions of import regulations, small business loans, etc. Even more important in the long run is the matter of encouragement of reading and the use of books through libraries, village councils, corporations, unions, and other institutions.

(a) Institutional support is of special importance in the field of children's books; and it must be remembered that for a long time to come the overwhelming majority of all book readers in developing countries will be young people. The juvenile book industry in the United States is made possible by institutional purchase. More than 75 percent of all children's books in the United States are bought by institutions, chiefly school and public libraries; whereas there are countries in Asia and Africa in which a book publisher cannot count on more than 1 percent of his sales income from such sources. Massive institutional purchase not only supplies a firm economic base of direct sales but, by permitting manufacture in editions far larger than would otherwise be possible, lowers unit costs and spreads overhead, thereby lowering retail selling prices and increasing sales to the general public.

11. Subsidy of publication is too often a deceptively tempting device for trying to increase book distribution, especially for foreigners with money in their hands. Corruption and inefficiency tend to arise, though this danger may be minimized to some extent by requiring substantial investments from the publisher to match the subsidy. Moreover, subsidizing of publishers encourages growth of a book industry on a false economic basis, and it tends to produce surpluses of some titles in the market and shortages of others. Yet it is undeniable that at least pump-priming economic assistance can be very helpful in getting a book industry started. The safest and in the long run the most effective method of economic help subsidizes the purchaser rather than the publisher. In some countries (e.g. Indonesia as to all university textbooks and the United States under the Veterans Bill) there have been large-scale attempts at subsidizing individual student purchasers through some system of scrip or warrants. That is ideal if administrative complications do not frustrate the purpose. But the easiest way of subsidizing purchase is through institutions, especially libraries. And that method not only gives economic support in healthy form but at the same time puts books into circulation.

12. A book industry is a suitable object of economic development in its own right. Because it does not bulk large in direct financial terms, its claim on the attention of economic planners has been slight, yet it has much to recommend it. A book industry need not follow an inflexible pattern but can adapt itself to local conditions. It is well suited to public-private cooperation, and its demands on capital and manpower are not exorbitant. One of the most attractive features of the book industry is that it gives almost classic illustration of the principle of small margin and large volume. Furthermore, soaring numbers of literates assure that the market will expand automatically for decades to come, thus giving even greater encouragement to those entrepreneurs who follow the "small-margin" principle. And because mass-market distribution in provincial areas as well as in metropolitan centers would be a basic part of the plan, the business influence of the book industry could extend far beyond the metropolis. The book industry, in short, can provide an ideal school for small-business development.

Conclusion

13. But those last thoughts are suggested as extra considerations for economic planners. They are mere supplements to the main argument for indigenous book industries in developing countries. Books are the basic tools of education, which is itself the basic capital investment for economic development. Education is as fundamental as dams and highways. Indeed, without education dams and highways cannot be used. Indigenous industries for the production of books are necessary if there is to be a continuing supply of books that are responsive to local needs. When a country establishes an educational system it makes a commitment leading inevitably to assumption of responsibility for establishment and maintenance of a local book industry.

Identification and Development of Talent in Young Children

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1. The task of a country in the early stages of industrialization includes the absolutely staggering problem of how to devise a wise educational system. The task is particularly difficult in a country undergoing rapid social and economic change where the demands for educated people will be much greater in 10 years from now than at the present time. While this particular paper is specifically directed to only a tiny aspect of the general problem, it is important to see the educational problem as a whole and in a national context. A general viewpoint is important because it is all too easy to take a narrow view of any particular academic issue and to lose sight of its many ramifications within the complex social structure of a rapidly developing country.

2. The task of designing a complete educational system is far outside the scope of this or any other single paper. It is a task which will present particular difficulties to newly developing countries with untested populations, unknown resources, and uncertain demands for educated personnel. In principle, however, the task of an educational system can be described in a not too complicated way. An educational system is after all one institution within a complex social order, inter-related to other such institutions as labor, management, the government, the family, etc. In this social order, the educational system has certain definite functions to perform. Furthermore, it must be responsive to the effects of its policies on the social order so that some kinds of self-corrective measures are initiated if the system becomes mal-adapted. Regardless of how well it might perform its formal functions, if an educational system arouses hostility or resentment or contempt in a large proportion of the populace, it will be changed willy-nilly or destroyed.

3. What then are these functions of the educational system? One important function of an educational system is to produce trained personnel, fitted to fill the jobs that the country has available for these people. To a certain extent, of course, the trained personnel create the jobs that they are to fill, but broadly speaking there cannot be too much dis-

crepancy between the level of training of a substantial segment of the population and the tasks these individuals must perform to contribute to the further growth and development of the country. The discrepancy can of course be in any of several directions. At the moment, the crying need in many developing countries is for people with sufficient education to take up important leadership roles in the industrial and political segments of society. Another serious shortage is that of the skilled laborer, able to function in a modern technology although not at the level of top management. While at the moment shortages in educated personnel exist at all levels, it is by no means inconceivable that a too great production of trained personnel at some particular level might outstrip current opportunities and market demands for their services. In a country with a limited industrial system the balance may very well be a rather critical one.

4. The highly industrialized countries of Western Europe and North America, where the opportunities for productive unskilled labor are rapidly declining, must look forward to providing everyone an education that heretofore has been accessible only to a minority. In many less developed countries, however, where labor is more economical than equipment, there will probably continue to be important tasks to be performed by unskilled laborers for a number of years. While it may seem quite unrealistic at the present time to worry about an over-supply of skilled labor, the task of planning an educational system should not neglect that possibility.

5. To conceive of the function of an educational system as solely that of providing trained personnel for jobs is quite incomplete. Not only trained managers, entrepreneurs and laborers are essential for the modernization and industrialization of the new country, but even more important is the creation of a literate populace to whom new information is accessible. Radical social changes are obviously required in all rapidly developing countries, and literacy is almost an essential for the effective communication of the information which will explain and bring about the social changes that are required. While perhaps literacy is most important, all the other aspects of "fundamental education", such as health, sanitation, etc., are important for the development of new countries and they must ordinarily be provided for within the formal educational system. Precisely because the country is rapidly developing, these kinds of fundamental educational skills and training can hardly be left to the home to be inculcated as part of the naturally occurring socialization process.

6. Still a third function of the educational system of the less developed countries is the much more intangible one of inculcating the motivation for social change and modernization. A motivation for achievement and the attitudes that promote social change will eventually be well rooted in the citizenry of the country, but in the early phases of its development, these kinds of motivations cannot be expected to develop within the family that is tied to the traditional system. While modern social science has but little advice to offer for the attainment of this educational objective, it is important to examine with whatever wisdom we have the possible consequences of educational policies on the motivation of the citizenry of a new country.

7. This paper will be concerned with only one small aspect of the final function in the above list, but it is important

to keep the context in mind and to maintain sensitivity to the indirect ramifications of whatever educational policy is under consideration.

8. The primary topic of this paper is the utilization of talent and by this we mean the utilization of unusual talent. It is easy to become sentimental about the utilization of talent and to feel that there is an inherent obligation for a social system to maximize and utilize all the latent talents of all its members. It is important, therefore, to recognize the fact that wastage of talent is not necessarily socially dysfunctional. It is entirely possible that there are potential talents in a society that are not very useful to it; this is perhaps more likely to be true in a less developed, less industrialized social system than in a well established country.

9. But if there may be dangers of developing useless kinds of talent in a society, high level, intellectual talent is surely not included. It seems very difficult to imagine even a small newly industrialized society having too many intelligent entrepreneurs, managers, and social leaders. We need to increase markedly the number of such people.

10. The problem of producing highly intelligent and sophisticated people in appropriate numbers involves two issues. The first of these is the identification of the potential leaders, the potential managers, and the potential intellectuals in the society. The second problem is concerned with the development of these potentialities through formal education, or some other social process.

11. There are in a sense two rival systems for the development of this sort of intellectual talent. The distinction between the two systems is by no means a sharp, black and white one, but, nevertheless it exists. In many countries there is an explicit plan for selecting the potential elite of the society at a relatively early age and providing that group of children with an especially stimulating educational environment, a highly demanding educational curriculum and more than its share of educational opportunities. Out of this group come almost all government leaders, industrial managers, and practitioners of the various legal, medical, and academic professions.

12. The alternative system which is espoused in the United States and some other countries is to leave the selection process to the naturally occurring factors that result in voluntary drop outs from school by students who perform badly and to delay formal selection procedures to the point where the student is actually an applicant for a university or a responsible job. Thus, students for universities are selected at the time they apply rather than at the age of 8 or 11 or 12. A fair amount of the weeding out of the unsuitable occurs after admission to educational institutions or to professional jobs themselves.

13. The arguments for the two points of view are quite familiar and unfortunately neither position is well buttressed with empirical evidence. Proponents of the policy of early selection point to its efficiency; they deplore the tremendous wastage of investment in bringing students through to the end of an educational career only then to discover that they are unsuited for the profession that they planned to enter. Proponents of the early selection system also point to the fact that a much better and more advanced educational program can be provided for the selected group if the clientele is not diluted by the less competent and less able.

14. The arguments on the other side

are equally familiar but speak at cross purposes to the arguments just recited. Proponents of the freer more flexible system point to the importance of permitting changes and plans as late as possible, they point to the inability of students at young ages to be motivated for the kinds of later careers for which they may well be suited, and they point to the difficulty in making the predictions that are involved in the early procedures.

15. Let us look first at the efficiency of the early selection policy without any regard for broader issues like democratization of education or the injustice that appears to be involved in an early selection procedure. The efficiency of such a plan depends among others upon the following empirical considerations. If an elite group is selected at any particular age, what percentage of that group would be chosen for the same elite if the selection were done at maturity? To make the issue concrete, if the top 1 percent of the children at age 5 were selected, what percentage of that group would be in the top 1 percent of adults at age 25. This measure of efficiency, of course, indicates how much of the investment that is put into the selected group is partially or completely wasted by virtue of the fact that they are unable to perform the functions for which they were trained.

16. The data, of course, are not available for an accurate appraisal of this wastage of educational resources in the context of a developing country, but one bit of relevent information is the later experience of the group of gifted children studied by Professor Terman and his colleagues. (1) He picked a group of children well within the top 1 percent of the population in terms of intellectual ability. Actually, he picked fewer than 1 per cent of the population, but we might take this group as representing the top 1 percent. Twenty years later this same group of children was retested. As well as we can estimate it, it seems that approximately 40 percent of the original gifted group were in the top 1 percent of the population 20 years later. The group as a whole was clearly superior to the average, and only 6 percent of the gifted group were below average in intellectual functioning as adults; nevertheless, more than half of them no longer met the criteria of being in the top 1 percent of the population. This group was originally picked among children from the third to eighth grades and, therefore, was originally tested after the period of highly unstable intelligence quotients that are characteristic of the pre-school years. If the same selection had been made at the age of 5 or 6, there would have been a substantially smaller percentage who remained in the top 1 percent of the population.

17. Several factors need to be considered before we draw a serious analogy between these results and those that would be expected from the policy of early selection of talented children to receive a special elite education.

18. The gifted children that Terman selected were not put into any special educational program designed to capitalize upon their high level of talent. Had they been recipients of such special educational efforts, a higher percentage of them might have remained in the top one percent. Actually, however, a great many of the gifted children in the Terman group did receive special educational attention because they came from families above average in social-economic level. These educational advantages included private lessons, attendance at preparatory schools, and encouragement to continue on for university education.

That the gifted children did receive more education than the non-gifted children is an established fact.

19. Another difference between results of Terman's study of gifted children in the United States and the results to be expected from a policy of early selection of talent may be differences in the predictability of intellectual ability in different cultures. This predictability may well be lower in a country in the early stages of industrialization where a large proportion of the population is in impoverished circumstances. Children entering school in such countries are probably comparable in many ways to children from lower economic levels in many industrialized societies and to those special groups of children raised in back-woods areas or in peculiarly unstimulating environments. Under these conditions, it seems very likely that the intellectual potentialities of the child are less manifest by the age of 6 or 8 than they are in an industrialized society.

20. A third factor to be considered in generalizing from the study of gifted children is the fact that the children not chosen for inclusion in the sample were not educationally deprived in any way. If one were interested solely in keeping the top 1 percent of the children in the top 1 percent of the adult population, it would be easier to deprive the 99 percent than to accelerate the 1 percent.

21. Nobody wants to deprive the less able children, but putting extra resources into the education of the elite may have that effect. The mere absence of the highly talented group from a class decreases the stimulating quality of the educational atmosphere. Teachers in Germany report that after the selected group of fourth graders move on to preparation for academic and professional careers, the heart is taken out of the class. The remainder are not nearly as interesting a group or as educable a group. It seems obvious that if any large proportion of the educational investment went into the training of the specially selected group, there would be proportionally less resources available for investing in the education of the general level.

22. The efficiency of the policy of early selection for talent must be evaluated also in terms of how many talented people are missed by such a program. Inefficiency occurs not only through wasting educational resources on people who are not able to profit from them, but also from the failure to develop the latent talent that is present in the group that fails to be selected for special educational effort. Quantitative estimates of this error of prediction are more difficult to obtain, but we would probably be not far wrong if we assumed that 60 percent of the adults who are in the top 1 percent of intellectual ability were below that range at the third grade level. If, therefore, the top 1 percent represents the elite that we wish we had educated, more than half of them will have been missed by a selection procedure at the level of the third grade.

23. How serious this inefficiency is depends upon how critical is the utilization of all the available high level talent in the country. If, for example, all the available tasks that require high level talent can be filled by the people who are selected, even though there is a 60 percent loss, then the missed opportunities of the other 40 percent are unfortunate and unjust from the point of view of the individual, but from a strictly functional point of view they are not critical. It seems, however, that in a newly developing country where such talent is ex-

tremely important and is needed in such quantities, it would be serious to pass up 60 percent of the available talent by a selection procedure.

24. Another problem of prediction lies in the use of intelligence tests for the selection of future leaders. Almost the only measures of children that could be used are measures of intellectual functioning, yet the follow-up study of the gifted children shows that even those who are highly intelligent are not necessarily leaders. About 70 percent of the gifted children held occupations as adults in the top two occupational classifications, i.e., professional and semi-professional and higher business occupations. About 13 percent of the employed male population of the United States hold these positions. So again we find that only 70 percent of the top 1 percent of children land in the top 13 percent of the occupations. The results are far better than chance, of course, but not very impressive as a selection procedure.

25. From the point of view of efficiency, therefore, it seems that selection as early as the third grade leaves much to be desired in the way of an adequate selection of the eventual elite group. No firm recommendations for or against such a procedure can be made without more precise information about the particular demands of the country. It would appear, however, that caution is well advised before adopting a policy of an irreversible selection of children who are to receive intensive educational opportunities.

26. Quite aside from the efficiency of the selection procedure, it is well to consider in a more general way some of the auxiliary consequences that might be entailed by a policy of early identification. It would certainly reduce the amount of resources available for investment in education of the unselected group, and the consequences of this deprivation must depend upon the magnitude of the reduction. Probably no one would recommend that the entire educational effort of a country would go into the training of a select group. It seems almost inconceivable that fundamental education for the entire population would not receive a priority as high as intensive cultivation of the highly talented child.

27. Whether the procedure would produce a discontinuous array of talents at various intellectual levels is difficult to appraise without the concrete details of a particular country in mind. In view of the fact that there is certainly an important need for skilled labor and for people at the level of foremen and subordinate supervisory personnel, it would seem essential that the educational system should produce people at various levels of training and that there should not be a large gap between a top group and the rest of the population. Of course, the mere failure of the selection procedure would insure a certain amount of spread of the highly trained down through the ranks, but the provision of adequate training at all levels should be an explicit, not an incidental, consequence of an educational policy.

28. Not only would a gulf between an elite and the rest of the population be disadvantageous from the point of view of vocational selection, but it would surely carry some political and social dangers. One of the hindrances to social change in the less developed countries is frequently the existence of an already entrenched elite who have much emotional investment in the traditional way of life. It seems all too likely that an early selection procedure would likely select chil-

dren from these advantaged families and that such a procedure might, therefore, lead to actual resistance against modernization.

29. It is apparent that the author of this paper cannot see the wisdom of an extreme strategy of selecting highly talented children at a young age and providing them with extraordinary educational opportunities at the expense of the general educational system. At the same time, it is not necessary to support a completely unselective procedure. There are alternative strategies that might be devised. For example, there might be a series of selections so that an error at one level would not have such serious consequences. Or there might be provision for reconsideration of rejected students in order that those people who may develop abilities or motivations later than usual may be captured for the important leadership roles so necessary in the growth of the less developed countries.

REFERENCE

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